Not My Fault!
Leveraging ESG-Scores for Strategic Resilience Against Peer-Originated Shocks

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Abstract

Scandals such as Dieselgate, Deepwater Horizon and the Boeing 737 MAX crisis have far-reaching effects that extend beyond the company itself and impact the reputation of other innocent firms industry-wide. The latest ESG literature highlights that companies having strong sustainability management and sustainable practices may have also the potential for greater resilience against such unexpected peer-originated reputational crises. This study tests the two hypotheses that ESG has a positive risk-mitigating effect on shocks caused by peer-originated and that there is a strategic match between the ESG factor and the respective crisis. This thesis uses a quantitative approach combining synthetic control and difference-in-differences, and investigates the resilience of firms in the automotive sector during reputational crises, with a focus on corporate governance as a resilience factor using Volkswagen's diesel emissions scandal in 2015 as a case study. The results show that (1) ESG acts as a protective shield against shocks from peer-originated and (2) governance as a strategic adjustment has the strongest effect in governance-related crises. The implications of these findings highlight the importance of ESG, particularly governance, as a short-term protective mechanism during reputational crises, emphasizing the need for firms to strategically align their governance practices to mitigate immediate reputational and financial damage.

Keywords: *Resilience - Reputational Crises - ESG - Synthetic Control Method - Dieselgate*

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Sumário

Escândalos como os da Dieselgate, da Deepwater Horizon e a crise do Boeing 737 MAX têm efeitos de grande escala, que ultrapassam a própria empresa e afetam a reputação de outras empresas inocentes em todo o sector. A literatura ESG mais recente salienta que as empresas com uma forte gestão da sustentabilidade e práticas sustentáveis podem também ter potencial para uma maior resistência a essas crises de reputação inesperadas, originadas pelos seus pares. Este estudo testa as duas hipóteses de que o ESG tem um efeito positivo de atenuação do risco em choques causados por crises originadas pelos pares e que existe uma correspondência estratégica entre o fator ESG e a respetiva crise. Esta tese utiliza uma abordagem quantitativa que combina controlo sintético e diferença-em-diferenças, e investiga a resiliência das empresas do sector automóvel durante as crises de reputação, com foco na governação das empresas como fator de resiliência, utilizando o escândalo das emissões de gasóleo da Volkswagen em 2015 como estudo de caso. Os resultados mostram que (1) o ESG atua como um escudo protetor contra os choques originados pelos pares e (2) a governação como um ajustamento estratégico tem o efeito mais forte nas crises relacionadas com a governação. As implicações destas conclusões sublinham a importância dos ESG, em particular da governação, como mecanismo de proteção de curto prazo durante as crises de reputação, enfatizando a necessidade de as empresas alinharem estrategicamente as suas práticas de governação para mitigar os danos imediatos de reputação e prejuízos financeiros.

Palavras-chave: *Resiliência - Crises de reputação - ESG - Método de controlo sintético - Dieselgate*

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Declaration of Authorship

I hereby declare that I have written this thesis independently, using only the resources and literature cited, and that the thesis has not been used to obtain any other academic title. During the preparation of this thesis, I used the artificial intelligence program ChatGPT to correct code in R, convert tables and plots to LaTeX-format and check grammar. After using this tool/service, I reviewed and edited the content as necessary and take full responsibility for the content of this thesis.

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1 Introduction

"Reputation is an idle and most false imposition, often got without merit and lost without deserving."

– William Shakespeare, *Othello*

Company reputations are widely recognized as a strategic asset, as highlighted by Adeosun and Ganiyu (2013). While Shakespeare's *Othello* addresses personal reputation, where the false assumption of adultery leads to tragedy, his observation of the undeserved loss of reputation and its severe implications applies equally to the corporate world, as noted by Jonsson (2001).

The 2015 diesel scandal is a prominent example of corporate misconduct at Volkswagen, which not only damaged its reputation but also had significant ripple effects across the automotive sector. Similarly, the Deepwater Horizon oil spill altered perceptions of environmental responsibility in the energy sector, the Boeing 737 MAX crisis raised safety concerns for all aircraft manufacturers, and Johnson & Johnson's talcum powder lawsuits affected public trust in the pharmaceutical and consumer health industries. These crises exemplify peer-originated shocks, where the fallout of one company's actions extends to its peers, reshaping market perceptions and industry stability.

This thesis investigates two key hypotheses based on *Stakeholder Theory* (Freeman, 1984) and the *Resource-Based View (RBV)* (Barney, 1991). First, strong ESG performance acts as a protective shield against peer-originated shocks. Second, the effectiveness of ESG factors depends on their strategic alignment with the crisis type. For instance, environmental (E) components may be critical for environmental crises like Deepwater Horizon, while governance (G) factors are pivotal in governance-related crises like Dieselgate. Resilience is not merely about the presence of ESG factors but their alignment with the type of shock to mitigate reputational and financial damages effectively.

To test these hypotheses, this thesis employs a quantitative approach, integrating the Synthetic Control Method (SCM) and Difference-in-Difference (DiD) analysis. Data is provided by Compustat for stock prices and controls, and by Refinitiv for ESG. SCM will construct counterfactuals to measure the unique impact of reputational crises on affected firms, while DiD will assess the differential impact of ESG alignment across firms and industries. Together, these methods offer robust insights into the shielding effects of ESG factors and the critical role of their strategic alignment, as both hypothesis finds support in the context of Dieselgate crisis.

The thesis is structured as follows: The theoretical framework introduces Stakeholder Theory and the Resource-Based View, followed by a discussion on ESG factors and resilience. The methodology outlines the application of Synthetic Control Method and Difference-in-Difference analysis. Subsequently, the results and discussion chapters examine the impact of ESG alignment on resilience, concluding with implications and future research directions.

2 Literature Review

2.1 Theoretical Background

Capital market shocks are significant, often unforeseen events that cause rapid and substantial price fluctuations in financial markets. According to Fama (1970), efficient markets instantly reflect all available information in asset prices. Therefore, market shocks—triggered by unexpected events or news—can lead to abrupt changes in the valuation of companies. This places immense pressure on firms to be prepared for such events. As Fama (1970) suggests, companies need to have strategies in place to mitigate the immediate impact of these shocks on their financial performance. In contrast, Minsky (1992) introduces the "Financial Instability Hypothesis," which highlights that financial markets are inherently unstable. Minsky argues that speculative behavior and bubbles in the market inevitably lead to crises, which are systemic to capitalist systems. These shocks are not isolated incidents but rather recurring disruptions that businesses must prepare for. Thus, companies must recognize that shocks are an inherent part of the market cycle and plan accordingly.

These perspectives highlight the need for firms to anticipate disruptions and develop strategies to mitigate immediate impacts while ensuring rapid recovery. Resilience, in the context of organizations, refers to the ability to withstand external shocks and recover quickly from them. According to Horne III and Orr (1998), resilience is "a fundamental quality (...) to respond productively to significant change that disrupts the expected pattern of events without engaging in an extended period of regressive behavior." This definition treats resilience as an *outcome*, focusing on how well companies respond to and recover from disruptive changes. Reducing performance impact of a shock is an accepted manner of measuring resilience and that in market shocks this application will enable development of valuable insights.

The *shareholder theory* and the *stakeholder theory* leads to two distinct resilience strategies that the companies can employ, when they face market shocks.. According to Friedman (1970), shareholder theory posits that the primary responsibility of a company is to maximize profits for its shareholders. In the context of capital market shocks, this often translates to short-term strategies focused on stabilizing share prices, even if these measures are not sustainable in the long run. On the other hand, Freeman (1984) argues for the stakeholder theory, which suggests that companies must consider the interests of all stakeholders, not just shareholders. By building long-term relationships with various stakeholders (customers, employees, suppliers, etc.), companies can create a more stable network of support, making them more resilient to external shocks. This broader focus allows companies to navigate crises with a more balanced approach that prioritizes long-term stability over immediate financial gains. Given the increased focus on the network of stakeholders and the external actors, any externality becomes a relevant factor to managing an organization, at times locating the source of the crisis in the larger business ecosystem.

2.2 Reputational Spillover

In some cases, the effects of a capital market shock are not limited to the company at its origin but extend to other firms or sectors, creating a spillover effect. Jonsson (2001) highlights how deviant behavior by one organization can lead to reputational losses for other, non-culpable organizations within the same industry. For example, in the automotive industry, a scandal at Volkswagen could have consequences for other car manufacturers, even if they were not directly involved. Similarly, the Deepwater Horizon oil spill impacted perceptions of environmental responsibility across the entire energy sector, while the Boeing 737 MAX crisis raised safety concerns that extended to other aircraft manufacturers. Likewise, Johnson & Johnson's talcum powder lawsuits cast a shadow over the pharmaceutical and consumer health industries, influencing public trust and market performance beyond the directly implicated company. This phenomenon underscores the importance of understanding how external shocks can propagate through industries, affecting firms that may not be directly responsible.

Spillover effects are particularly relevant in the context of resilience, as they highlight the need to go beyond the strategies of individual firms and consider the broader, interconnected dynamics of industries and markets. Resilience, as previously defined, is the ability of organizations to withstand and recover from external shocks. However, when shocks propagate across firms and sectors, resilience must also be understood at a systemic level. Addressing spillover effects requires not only robust individual strategies but also coordinated efforts within industries to mitigate collective risks and preserve legitimacy.

The occurrence of spillover effects can be explained through several theoretical lenses. The legitimacy theory (DiMaggio and Powell, 2000) suggests that firms derive their legitimacy from aligning with societal norms and expectations. When one firm violates these norms, it can lead to a broader legitimacy crisis, where other firms in the same industry come under scrutiny, even if they are not directly culpable. This effect is particularly pronounced in industries with shared reputational characteristics, such as the automotive or pharmaceutical sectors. Such legitimacy crises underscore the importance of resilience as a collective attribute, where firms work together to rebuild trust and align with societal expectations.

Social network theory (Granovetter, 1973) further elaborates that firms are embedded within interconnected networks where reputational and informational flows occur. A negative event in one part of the network can rapidly disseminate through these connections, amplifying the reputational damage to other firms within the same network or industry (Yu and Lester, 2008).

This interconnectedness highlights the relational dimension of resilience, where the ability of a firm to withstand shocks is influenced by the resilience of its network and the collective capacity to manage reputational risks.

Signal theory (Spence, 1973) offers an additional perspective, emphasizing how corporate actions send signals to the market. A scandal at one company can signal to stakeholders, including investors and consumers, that similar issues might exist across the industry. This perception often results in generalized reputational damage and reduced trust, impacting firms beyond the origin of the crisis. Resilience, in this context, involves not only addressing the root cause of the shock but also actively managing the signals sent to stakeholders to prevent further erosion of trust.

The mechanisms by which these effects propagate are multifaceted. Reputational contagion plays a significant role, as stakeholders often reassess their perceptions of all firms sharing certain characteristics when one firm deviates from accepted norms (Paruchuri and Misangyi, 2015). Regulatory responses to scandals can also create industry-wide implications, as increased scrutiny and compliance costs affect even those firms not directly involved (Desai, 2011). Lastly, market perception mechanisms, driven by investor and consumer biases, exacerbate these spillovers by generalizing individual firm behavior to the entire sector (Jonsson, 2001).

Understanding and addressing these theoretical and mechanistic insights is essential for fostering organizational and systemic resilience. Firms must not only address their direct vulnerabilities but also collaborate within their industries to strengthen collective resilience. This broader perspective extends the scope of resilience from an organizational to an industry-wide and even societal level, reflecting the interconnected challenges and opportunities posed by spillover effects.

2.3 ESG and Financial Resilience

Edmans and Kacperczyk (2022) highlight that ESG topics are increasingly discussed at the CEO level, extending beyond traditional Corporate Social Responsibility (CSR) frameworks. This shift illustrates how ESG has become crucial for investors, even those with purely financial goals. Companies adopting sustainable practices often benefit from fewer regulatory sanctions and higher customer satisfaction, which in turn strengthens their financial resilience.

To explore the connection between Environmental, Social, and Governance (ESG) practices and the financial performance of companies, several studies from leading academic journals offer valuable insights.The papers included in this literature review were sourced using Google Scholar with the keywords *"ESG," "Financial Performance," "Financial Resilience," "Sustainability,"* and *"Governance Risk"*.

Following the definition provided by the United Nations, Environmental, Social, and Governance (ESG) refers to three central dimensions used to evaluate the sustainability and societal impact of an investment or a company (Kostic´ et al., 2023). The Environmental dimension assesses a company's impact on the natural environment, addressing issues such as greenhouse gas emissions, resource consumption, waste management, and efforts towards environmental protection. The Social dimension includes factors such as working conditions, employee health and safety, diversity and inclusion, human rights, and the company's influence on local communities. Lastly, the Governance dimension examines a company's internal processes and practices, including transparency, ethical conduct, board composition, anti-corruption measures, and its relationship with shareholders.

Albuquerque et al. (2020) examined the financial resilience of ES-focused companies during the COVID-19 pandemic. They found that companies with high ES scores experienced lower volatility and higher stock returns, demonstrating improved resilience in the face of economic shocks. Similarly, Whelan et al. (2021) confirm in their meta-analysis that ESG investments typically show a positive correlation with financial performance, reinforcing the idea that ESG serves as a long-term stabilizing factor.

The effects of ESG vary across industries and regions. Jo and Na (2012) studied the influence of CSR in controversial industries, finding significant differences across sectors. Companies in environmentally critical industries benefited particularly from ESG initiatives. In contrast, Naffa and Dudás (2024) found that in emerging markets, the resilience effects of ESG were less slightly negative, suggesting that the effectiveness of ESG depends heavily on geographic and sectors.

Wang et al. (2023) link ESG with financial allocation efficiency, suggesting that ESG can be used strategically to enhance a company's resilience to crises and improve financial performance. This perspective aligns with the *Resource-Based View (RBV)*, discussed earlier in the theoretical framework. ESG, as an intangible asset, can provide companies with long-term competitive advantages.

The following table summarizes key studies examining the relationship between ESG practices and financial resilience. The table highlights the methodology, dependent and independent variables (with a focus on whether Environmental (E), Social (S), or Governance (G) factors were emphasized), and the outcomes of these studies. These studies indicate that ESG criteria can offer companies long-term resilience, particularly during crises.

Table 2.1: Overview of ESG Studies (Non-Exhaustive)

Author	**Content**	**Dependent Variable (Resilience Measure)**	**Explanatory Variable**	**Results**
DesJardine et al. (2019)	*Qualitative analysis of resilience in the 2008 financial crisis*	*Maximum drawdown and recovery rate*	*Social and environmental practices (E/S)*	*Firms with strong social and environmental practices showed better resilience (Positive)*
Danso et al. (2020)	*Regression analysis of stakeholder integration and financial performance*	*Various fundamental financial data, e.g. ROI,ROA, ROE*	*Stakeholder integration, sustainability (E/S/G)*	*Stakeholder integration and sustainability improve financial performance (Positive)*
Albuquerque et al. (2020)	*Empirical analysis using stock returns and volatility during COVID-19*	*Stock returns, volatility*	*ES scores (E/S)*	*High ES scores led to better resilience during COVID-19 (Positive)*
Sajko et al. (2021)	*Analysis of resilience to systemic shocks*	*Price drop and recovery rate*	*CEO greed, CSR*	*CSR positively moderates resilience, while CEO greed is negatively associated*
Gianfranco et al. (2021)	*Quantitative analysis of European financial market data during COVID-19*	*Abnormal stock returns*	*ESG investments (E/S/G)*	*ESG benefits certain industries more (Positive)*
Dinca et al. (2022)	*Regression analysis of ESG factors in the automotive sector*	*Firm value in the automotive sector*	*ESG factors (E/S/G)*	*ESG factors have a mixed impact on firm value in the automotive sector (Mixed)*
Wang et al. (2023)	*Empirical analysis of ESG's effect on financial allocation*	*Capital allocation efficiency*	*ESG factors (E/S/G)*	*ESG improves financial allocation efficiency and resilience (Positive)*
Ameur et al. (2023)	*Statistical analysis of green assets during crisis periods*	*Mean Conditional VaR*	*Green Assets (E)*	*Green asset ratios significantly affect financial risk during crises (Positive)*
Berg et al. (2023)	*Statistical analysis six different ESG Scores*	*CAPM & FAMA French Alpha*	*ESG-Scores (E/S/G)*	*Mixed Results dependig on ESG-Factor and Rating (Mixed)*
Bax et al. (2023)	*Vine-Copula models to analyze risk components within ESG classes*	*Tail Risk*	*ESG-Scores (E/S/G)*	*Market and idiosyncratic risks vary (S & E Mixed/G Positive)*
Naffa and Dudás (2024)	*Analysis of financial resilience in emerging markets using firm-level data*	*Maximal drawdown*	*ESG implementation (E/S/G)*	*ESG impact is slightly negative in emerging markets (Negative)*

As shown in Table 2.1, the majority of studies highlight a *positive correlation* between ESG factors—especially Environmental (E) and Social (S)—and financial resilience. For instance, studies by Gianfranco et al. (2021) and Albuquerque et al. (2020) confirm that companies with strong ESG performance experienced greater stability during crises such as the COVID-19 pandemic. Interestingly, when focusing specifically on tail risks, as explored by Bax et al. (2023), governance appears to play a particularly critical role in supporting financial performance during periods of crisis.

However, there are some studies, such as Dinca et al. (2022), which present *mixed results*, particularly in sectors like the automotive industry. These findings suggest that while ESG practices may contribute positively to firm value in many cases, the relationship can be more complex depending on sector-specific factors. In emerging markets, as highlighted by Naffa and Dudás (2024), the impact of ESG on resilience is often *slightly negative*, indicating that the effectiveness of ESG strategies may vary significantly by region.

2.4 Hypothesis Development

The relationship between ESG performance and corporate resilience can be understood through a logical sequence that explains how ESG factors act as a signal to investors, build trust, and ultimately enhance resilience during peer-originated shocks. This framework draws upon the Stakeholder Theory (Freeman, 1984) and the Resource-Based View (RBV) (Barney, 1991), providing a comprehensive rationale for the protective role of ESG.

ESG performance serves as a critical signal to investors, stakeholders, and the broader market, communicating a company's values, strategic priorities, and ability to navigate uncertainty. According to Signal Theory (Spence, 1973), organizations with strong ESG scores send clear messages of stability and preparedness. Transparency and accountability in ESG disclosures reduce information asymmetry and reassure stakeholders of a company's reliability. Ethical leadership and robust governance structures further strengthen this perception, demonstrating the organization's capacity to manage risks effectively. Strong environmental and social performance highlights proactive risk management and long-term thinking, reinforcing the notion that these companies are well-prepared to face disruptions. This signaling helps investors differentiate between culpable and non-culpable firms during crises, reducing the contagion effects of peer-originated shocks.

Building on this signaling function, ESG fosters trust, a crucial intangible asset in stabilizing stock performance during crises. Trust is cultivated through consistent, transparent, and ethical actions—all core elements of high ESG performance. Companies that establish trust benefit from increased investor loyalty, reducing the likelihood of panic-driven sell-offs and price volatility. Moreover, trusted firms are perceived as lower-risk investments, a critical factor during peer-originated shocks when markets often generalize blame across entire sectors. Trust also galvanizes support from other stakeholders, such as employees, customers, and suppliers, ensuring operational stability during turbulent times. Empirical evidence, such as Guiso et al. (2008), highlights the economic value of trust, showing that it lowers capital costs and strengthens corporate resilience to external shocks.

The components of ESG—Environmental, Social, and Governance—further reinforce resilience by addressing key aspects of a company's operations and strategic outlook. Strong environmental practices showcase innovation and sustainability, reducing exposure to resource scarcity and regulatory penalties. Social factors, such as robust employee relations and community engagement, build goodwill and reduce reputational risks. Employees in socially responsible firms demonstrate higher morale and loyalty, while communities are more likely to support such companies in crises. Governance, the backbone of ESG, ensures robust risk management, accountability, and ethical decision-making, equipping companies to navigate challenges effectively.

During peer-originated shocks, such as sector-wide reputational crises, ESG scores act as a protective buffer for non-culpable companies. High ESG scores enable investors to distinguish between implicated and uninvolved firms, mitigating the spillover effects of negative sentiment across a sector. Furthermore, these scores reinforce stakeholder confidence, signaling that the company's practices are aligned with ethical and sustainable standards, even amidst industry turmoil. ESG performance also attracts purpose-driven institutional investors who prioritize sustainability, creating a more stable investor base less likely to react to short-term market fluctuations.

The culmination of ESG signaling, trust-building, and operational preparedness manifests as corporate resilience. Companies with high ESG scores experience lower stock price volatility during crises, as trust and investor confidence act as stabilizing forces. They also recover more quickly, leveraging their stakeholder relationships and operational stability to minimize the long-term impact of shocks. By reducing the likelihood of reputational damage and maintaining access to critical resources, high-ESG companies sustain performance even in adverse conditions. This argumentation provides a robust foundation for the hypothesis that:

- $\mathbf{H}_1$: Companies with higher ESG scores are more resilient to peer-originated shocks than those with lower ESG scores.

Building on the premise that ESG factors contribute to corporate resilience, the question arises whether all components of ESG—Environmental, Social, and Governance—are equally effective in mitigating risks during crises. The nature of shocks is diverse; some are environmental, others social or governance-related. This diversity suggests that the relevance and effectiveness of ESG factors may depend on the specific type of shock, with certain factors aligning more closely to the demands of the crisis than others. This alignment, or lack thereof, determines the extent to which ESG factors act as strategic resources in the face of adversity.

Crises test the adaptability and relevance of corporate resources, and ESG components are no exception. The Resource-Based View (RBV) provides a theoretical lens through which ESG factors can be understood as strategic resources. These resources derive their value from their ability to address the specific challenges posed by a crisis. For example, during an environmental shock such as a flood, drought, or regulatory shift related to emissions, the Environmental component of ESG becomes particularly critical. Firms with strong environmental practices, such as resource efficiency, carbon neutrality, or sustainable supply chains, are better positioned to manage these crises. Their ESG strategies align directly with the external pressures of the shock, providing a targeted resilience mechanism. By contrast, in the same scenario, governance practices, while important for overall firm management, may not directly mitigate the risks posed by the environmental shock. Similarly, social practices, such as community engagement, may have limited immediate relevance to the environmental crisis at hand.

The concept of strategic fit, rooted in the RBV and the Strategic Factor Market (Barney, 1991), explains why this alignment matters. Strategic fit occurs when a firm's resources and capabilities align with external conditions, enhancing its ability to adapt and thrive. In the case of ESG, this means that the factor most relevant to the shock—whether Environmental, Social, or Governance—has the greatest impact on resilience. Firms with strong alignment between their ESG strengths and the crisis demands are better able to buffer the effects of shocks, recover more quickly, and maintain stakeholder trust. This alignment highlights the value of ESG not as a monolithic framework but as a collection of context-specific resources that require strategic deployment.

The dynamic nature of crises also emphasizes the importance of adaptability. While ESG factors are often viewed holistically, their relative importance shifts depending on the nature of the shock. For example, during a governance-related scandal, strong governance practices become the cornerstone of resilience, whereas environmental practices may play a supportive role. This dynamic prioritization underscores the need for firms to cultivate not only robust ESG practices but also the ability to realign and adapt their ESG focus in response to emerging crises. Ultimately, this reasoning leads to the hypothesis:

- $\mathbf{H}_2$: The risk-mitigating effect of an ESG factor is greater depending on the nature of the shock, with the most relevant ESG component having the strongest influence on resilience.

3 Research Design

3.1 Context

This thesis seeks an answer to the research question in the automotive context, which witnessed a significant Diesel emissions scandal, also known as "Dieselgate," emerged in September 2015. The Volkswagen Group admitted to using illegal software in millions of its diesel vehicles to manipulate emissions tests. As a result, cars were emitting pollutants up to 40 times the permissible levels during real-world driving. The scandal had immediate legal, financial, and reputational consequences for Volkswagen, as well as for the automotive industry as a whole. Reports from The Guardian and The Wall Street Journal extensively documented the global response to this scandal, revealing its wide-reaching implications beyond the immediate participants (Topham et al., 2015; Boston, 2015).

One of the key financial impacts of the scandal was a rapid loss of market value, initially wiping out around $ 56 billion from Volkswagen's market capitalization (Akin, 2016). Investors, despite earlier warnings from environmental groups and regulatory authorities, were caught off guard. The entire automotive sector experienced a synchronized adjustment in stock prices and credit default swaps, driven by a reassessment of risk across the industry (Akin, 2016). The scandal not only affected Volkswagen but also increased scrutiny of other manufacturers, amplifying concerns across the sector.

In this study, I focus on the broader automotive sector, particularly on companies that were not directly involved in the emissions fraud, such as other national and international engine manufacturers. These firms, though uninvolved, experienced reputational spillovers from the event. This is explained by Jonsson and Buhr's concept of "Lost Without Deserving" (Jonsson, 2001), which describes how the legitimacy of organizations with similar characteristics can be jeopardized due to the misconduct of one.

Particular attention is given to the Governance (G) component of ESG (Environmental, Social, Governance) scores in this thesis. Governance is a critical factor in assessing the resilience of organizations to reputational shocks, as seen in the aftermath of Dieselgate.

3.2 Data

This section provides an overview of the data selection and sources used in this analysis. The focus is on the top 20 global automotive manufacturers, based on rankings from Aranca's Top

50 Global Automotive Manufacturers (Aranca, 2024). These companies represent a broad geographic distribution and include electric vehicle manufacturers. Additionally, data from major supermarkets was included to construct a synthetic control group for the SCM analysis.

The stock prices for both the automotive companies and the supermarkets were sourced from Compustat (US and Global, Security Daily), providing daily price data essential for the analysis. ESG data was obtained from Refinitiv (Nikon Datastream), consistent with the approach of Albuquerque et al. (2020) and Gianfranco et al. (2021). Refinitiv's ESG data is widely used in sustainable finance literature and follows a bottom-up approach, assessing performance across three main pillars: Environmental (E), Social (S), and Governance (G). Control variables, including industry- and country-specific factors, were sourced from Compustat US and Compustat Global (Fundamental and Security Daily Fundamental). The Refinitiv ESG scoring methodology evaluates governance as one of three main pillars, alongside environmental and social factors, focusing on transparent, objective measures to assess a company's ESG performance Refinitiv (2022).

For governance, Refinitiv evaluates companies based on three primary areas: Management, Shareholders, and Corporate Social Responsibility (CSR) Strategy. Governance scores are benchmarked against the standards of the company's country of incorporation, recognizing that governance practices tend to be more consistent within national contexts. The evaluation includes several key metrics.

First, Management Structure encompasses aspects such as board independence, diversity, and committee structures, which collectively assess the quality of management and oversight within the organization. Second, Shareholders' Rights are evaluated through factors like voting rights and takeover defenses, which reflect the level of protection and empowerment afforded to shareholders. Finally, CSR Strategy focuses on the company's policies related to corporate social responsibility and their integration into governance practices, providing insight into the alignment of governance with broader societal and ethical commitments.

The scores use a percentile rank based on data transparency, frequency of disclosures, and presence of governance policies. Companies are compared within their peer group (by country), with ranks adjusted for relevance to the industry and disclosure levels.

In cases of **ESG controversies**, governance scores are penalized based on severity, with the goal of reflecting ongoing governance issues, such as lawsuits or regulatory disputes, impacting the ESG score for up to the next fiscal period.

Table 3.1: Summary of Data Sources

Data Type	**Source**
Automotive Stock Prices	WRDS Compustat
Supermarkets Stock Prices	WRDS Compustat
ESG Data	Refinitiv Eikon Datastream
Control Variables	WRDS Compustat

The data was consolidated into an Excel file. Duplicate companies, which appeared due to listings on multiple stock exchanges or the presence of different types of shares (e.g., preferred and common stock), were removed. To account for currency differences, particularly for Asian stocks, prices were indexed at the beginning of the year. This led to the creation of a new variable prccd_relative, replacing the original closing price variable prccd.

On certain dates, data points were unavailable due to holidays, variations in trading days across different exchanges, or missing values. These dates include January 1, 2015; January 19, 2015; February 16, 2015; April 3, 2015; May 25, 2015; July 3, 2015; September 7, 2015; November 26, 2015; December 25, 2015; October 21, 2015; and October 22, 2015.

To ensure a balanced dataset for the synth package in R, rows corresponding to these dates were removed for all companies. Although interpolation was possible, it was not performed, as the missing dates only affect the optimization phase and not the crisis period.

Table 3.2: Mapping of Governance Score to Numeric Level (1-12)

Governance Score	**Numeric Level**
D-	1
D	2
D+	3
C-	4
C	5
C+	6
B-	7
B	8
B+	9
A-	10
A	11
A+	12

To process the ESG data, the grades were converted into numbers (see Table 3.2). The Refinitive methodology defines numbers from 1-100, since we lack the insight to define these numbers, we set them to 1-12.

3.3 Methodology

3.3.1 Synthetic Control Method

The Synthetic Control Method (SCM) was implemented to analyze the impact of external shocks on the stock prices of automotive companies in comparison to the selected supermarkets. SCM is a robust method frequently used to isolate shocks and evaluate the effects of specific events on firms, especially in situations where randomized control trials are impractical.

SCM constructs a synthetic version of the treatment group by forming a weighted combination of control units that did not receive the intervention. This synthetic control serves as a benchmark for comparison with the treated unit before the intervention.

The method has been widely used in various contexts, including the evaluation of policy changes, natural disasters, and economic interventions. Notable studies that employed SCM include evaluations of California's tobacco control program Abadie et al. (2010), the impact of the Basque conflict on economic outcomes Abadie and Gardeazabal (2003), and the effects of vaccine mandates on childhood immunization Abadie (2021). The versatility of SCM in empirical research makes it an appropriate choice for this analysis.

The SCM approach combines elements from matching and difference-in-differences techniques. It uses a relatively long time series of outcomes prior to the intervention and estimates weights to ensure that the control group closely mirrors the treated unit. This is formally expressed as:

$$Y_{it}^{N} = \delta_t + \theta_t Z_i + \lambda_t \mu_i + \varepsilon_{it} \tag{3.1}$$

where Y_{it}^{N} is the outcome in the absence of the treatment. The synthetic controls approach suggests using these weights to estimate the counterfactual outcome:

$$Y_{1t}^{N} = \sum_{j=2} w_j Y_{jt} \quad \text{for } t > T_0 \tag{3.2}$$

This method offers a systematic approach to assigning weights to the control group and has been applied across various fields, including economics, political science, and health policy.

In implementing the Synthetic Control Method (SCM), the analysis utilized the Synth package in R (Abadie et al., 2011), which offers a structured framework for constructing synthetic control groups. Several key design choices were made during the analysis.

First, the selection of control units involved composing the control group from leading supermarket companies, enabling a robust comparison between the synthetic control unit and automotive companies. Second, the optimization of weights was conducted using pre-intervention data from January 1, 2015, to ensure that the synthetic control group closely resembled the treatment group in relevant characteristics.

3.3.2 Difference-in-Difference Regression

For this analysis, a Difference-in-Difference (DiD) approach is applied to evaluate the impact of the Diesel scandal on the stock prices of automotive companies compared to a synthetic control group constructed in the previous chapter using the Synthetic Control Method (SCM).

Previous studies often use financial resilience metrics, such as Maximum Drawdown and Recovery Rate, to measure the impact of shocks. However, due to the limited number of affected companies and the relatively small size of the focus group, these metrics were deemed unsuitable. Instead, the DiD approach was chosen as it is particularly effective for small samples and can isolate the shock's impact by comparing the performance of the treatment and control groups over time Bertrand et al. (2004).

The general form of the DiD model is as follows:

$$Y_{it} = \alpha + \beta_1 \cdot \text{Treatment}_i + \beta_2 \cdot \text{Post}_t + \beta_3 \cdot (\text{Treatment}_i \times \text{Post}_t) + \gamma \cdot \mathbf{X}_{it} + \epsilon_{it} \tag{3.3}$$

In this model, the dependent variable Y_{it} represents the relative stock price of company i at time t, normalized to the stock price on January 1, 2015. This normalization allows for a consistent comparison of price movements across companies. The variable Treatment_i is a binary indicator that identifies whether a company belongs to the automotive sector (assigned a value of 1) or to the synthetic control group (assigned a value of 0).

The variable Post_t is also binary, differentiating periods before and after the scandal. Specifically, September 18, 2015, marks the day the United States Environmental Protection Agency (EPA) released its accusations against Volkswagen, leading to a dramatic drop in the company's stock price. Periods before this date are coded as 0, while those after are coded as 1.

The interaction term $\text{Treatment}_i \times \text{Post}_t$ captures the differential effect of the Diesel scandal on the treatment group (automotive sector) relative to the synthetic control group. The coefficient β_3 associated with this term represents the DiD estimator, quantifying the causal effect of the scandal.

To account for firm-specific and time-specific characteristics, additional variables X_{it} are included in the model. These control variables—profitability, liquidity, and financial ratios—are not only crucial for understanding the financial context of each firm but also serve an important methodological purpose. They help isolate the effect of governance and broader ESG factors by controlling for financial characteristics that could interact with these variables. For instance, firms with higher profitability or liquidity may have more resources to invest in governance and sustainability practices, which could confound the relationship between governance scores and resilience. By including these controls, the analysis ensures that the observed effects are attributable to governance and ESG factors rather than underlying financial conditions.

Profitability is measured using Return on Equity (ROE), calculated as the ratio of earnings before interest, taxes, depreciation, and amortization to total equity (ebitda/teq). Liquidity metrics include the current ratio, defined as the ratio of current assets to current liabilities (act/lct), and the liquidity ratio, which compares cash to current liabilities (che/lct). These metrics, retrieved from Compustat, capture the firm's ability to manage short-term finan- cial obligations and are important for understanding crisis resilience.

In addition to financial controls, ESG scores play a critical role in this analysis. The environmental score (Environment) reflects a company's environmental impact, while the social score (Social) assesses its social responsibility. The governance score (Governance) cap- tures the quality of corporate governance, which is central to the research question as gover- nance quality is hypothesized to enhance resilience. A combined ESG score (ESG) aggregates these dimensions to provide an overall assessment of a company's sustainability performance. All ESG data were sourced from Refinitiv.

The key variables and their descriptions are summarized in Table 3.3.

Table 3.3: Variables for Difference-in-Difference Analysis

Variable	**Description**
Dependent Variable	
Price	Daily stock price relative to January 1, 2015, retrieved from Compustat
Independent Variables	
Treatment	Binary variable: Automotive sector = 1, Synthetic control group = 0
Post	Binary variable: Before the shock = 0, After the shock = 1, Shock date: September 18, 2015
Environmental (E)	Environmental score, retrieved from Refinitiv
Social (S)	Social score, retrieved from Refinitiv
Governance (G)	Governance score, retrieved from Refinitiv
ESG	Combined ESG score, retrieved from Refinitiv
Size	Revenue (revt), retrieved from Compustat
Profitability	Return on Equity (ROE, ebitda/teq), retrieved from Compustat
Current Ratio	Ratio of current assets to current liabilities (act/lct), retrieved from Compustat
Liquidity Ratio	Ratio of cash to current liabilities (che/lct), retrieved from Compustat

To evaluate the impact of the Diesel scandal on the stock prices of automotive companies, various versions of the Difference-in-Difference (DiD) model were employed. The analysis began with a basic model using all available data to assess the general effect of the scandal. This model provided a baseline understanding of how the stock prices of the automotive sector were affected relative to the synthetic control group.

Next, the analysis focused on geographic variations, as a particularly strong effect was anticipated in Europe, given the geographic proximity to Volkswagen (VW). A model restricted to European companies was constructed to capture these regional dynamics. Subsequently, a third model was run excluding European companies to evaluate whether similar effects could be observed outside of Europe or if the impact was primarily localized.

Following these initial models, the analysis shifted to testing individual ESG factors, starting with governance (G), as it forms the central focus of this study. Governance was incorporated using a triple interaction term (Treatment × Post × Governance) to investigate how governance quality moderated the impact of the scandal. This was conducted both with and without VW in the dataset, to ensure that the findings were not disproportionately influenced by the case of VW, which was directly implicated in the scandal.

Building on the governance analysis, the models were extended to include social (S) and environmental (E) factors. However, due to concerns about potential "halo effects," as highlighted by (Berg et al., 2022), which suggest that high scores in one ESG dimension may inflate perceptions of performance in others, all ESG dimensions were tested separately rather than being combined into a single model. This approach ensured a clearer understanding of the distinct contributions of each ESG factor to resilience during the crisis.

To further isolate the effect of the scandal and account for potential confounders, additional models were constructed with control variables and fixed effects. These models included firm-level controls such as profitability (ebitda/teq) and liquidity (che/lct, act/lct), which helped ensure that the observed effects were not driven by underlying financial conditions that could interact with ESG factors. Fixed effects for firms and time periods were also included to control for unobserved heterogeneity and time-invariant characteristics, further enhancing the robustness of the results.

3.4 Robustness & Validation

To validate the assumptions underlying the DiD models and ensure the robustness of the results, several diagnostic tests were conducted. First, correlation analyses were performed to confirm the parallel trend assumption, a key requirement for DiD models, ensuring that the treatment and control groups would have followed similar trends in the absence of the scandal. Next, the Breusch-Pagan test (Breusch and Pagan, 1979) was applied to check for heteroscedasticity, which is crucial for unbiased standard errors. When non-constant variance was detected, robust standard errors were used to address this issue (Angrist and Pischke, 2009).

The Breusch-Godfrey test (Breusch, 1978; Godfrey, 1978) was also conducted to assess autocorrelation in the residuals, particularly relevant for time-series data where residuals may be correlated across time periods. To detect potential multicollinearity among independent variables, a Variance Inflation Factor (VIF) analysis (Marquardt, 1970) was performed, ensuring that no variable was excessively correlated with others, which could distort the estimates. Additionally, the Ramsey RESET test (Ramsey, 1969) was employed to examine the functional form of the model and detect potential specification errors, confirming that the models adequately captured the relationships between variables without omitting critical interactions.

The Shapiro-Wilk test (Shapiro and Wilk, 1965) was used to examine the normality of residuals. While normality is not a strict requirement for DiD models, it enhances the interpretability of hypothesis tests (Gelman and Hill, 2007).

4 Results

4.1 Descriptive Statistics

4.1.1 Summary Statistics

The descriptive statistics for the selected variables provide an overview of key metrics in the dataset.

The governance score (Governance) shows an average value of 8.11, with scores ranging from 2 to 12, indicating significant variation in governance quality among companies. Similarly, the environmental and social scores (Environment and Social, respectively) exhibit averages of 9.47 and 8.21, with ranges from 1 or 2 to 12, reflecting the differences in environmental and social performance across firms. The overall ESG score (ESG) aligns with these values, with an average of 8.58 and a range from 1 to 12.

In terms of financial metrics, revt (revenue) has a mean of 1.63 million with a substantial standard deviation of 3.43 million, reflecting disparities in company size and revenue generation. The liquidity measures, act.lct (current assets to liabilities) and che.lct (cash to lia- bilities), have means of 1.045 and 0.443, respectively, with large standard deviations, indicating variation in short-term solvency among firms. These differences are essential for understanding the financial context of the companies in the sample and their potential resilience dynamics.

Table 4.1: Summary Statistics for Key Variables in the Dataset

Variable	Mean	Std. Dev.	Min	Max
Trading Day	124.50	71.60	1	248
Governance	8.11	2.71	2	12
Environment	9.47	2.82	1	12
Social	8.21	3.21	2	12
ESG	8.58	2.72	1	12
revt	1,631,565	3,436,221	3,198,356	13,328,100
act.lct	1.045	0.926	0	4.591
che.lct	0.443	0.843	0	4.285

4.1.2 Correlation Analyses

In addition to these descriptive statistics, the correlation tables in the appendix provide insights into relationships between various variables within the automotive sector. In figure 6.1, it becomes clear that correlations within the sector differ both before and after the Dieselgate scandal (the shock). Notably, there are shifts in dynamics among Asian companies compared to Volkswagen. These differences suggest that the scandal had impacts not only on Volkswagen but also on the entire sector, particularly concerning European markets.

The pre- and post-crisis correlation tables, 6.1 and 6.2, highlight regional patterns in the data. A high level of correlation is observed among European companies both before and after the shock, suggesting a strong interconnectedness within this region. In contrast, the correlations at a global level, particularly involving non-European companies, appear weaker. This observation aligns with the results of the regression analysis presented in subsequent chapters, where European companies exhibit more pronounced effects of the scandal.

Furthermore, these findings provide additional support for the parallel trend assumption, which is fundamental for the difference-in-differences (DiD) model applied later. Specifically, within Europe, the parallel trends hold, reinforcing the decision to focus the analysis on European markets. The geographic proximity to Volkswagen likely explains the stronger correlations and the observed spillover effects within Europe.

When comparing automotive correlations with the correlation tables for the control group of supermarkets (6.3 and 6.4), no shock effect is observed. The stability of supermarket correlations before and after the shock suggests that the effects of the Dieselgate scandal were sector-specific and did not cause significant changes in unrelated industries. This contrast further strengthens the robustness of the analysis and highlights the sector-specific nature of the Dieselgate impact.

4.1.3 Multicollinearity and Halo Effect in ESG Pillars

The correlation analysis between the ESG pillars reveals significant interdependencies, particularly between the Environmental and Social Pillar Scores, which have a strong correlation of 0.82. Similarly, the Environmental and Governance Pillar Scores show a moderate correlation of 0.67, while the Social and Governance Pillar Scores exhibit a lower but still notable correlation of 0.53.

These findings align with the "halo effect" described by Berg et al. (2022), where high performance in one ESG dimension can positively influence perceptions or ratings in other dimensions. This suggests that while each ESG component measures distinct areas, there is interdependence, especially between Environmental and Social scores, potentially impacting how resilience and corporate responsibility are perceived across these categories.

Table 4.2 summarizes the correlation values and highlights the overlap between ESG dimensions, underscoring the relevance of accounting for these interrelationships in resilience analysis to mitigate the effects of multicollinearity.

Table 4.2: Correlation Matrix of ESG Pillars

	Environment	**Social**	**Governance**
Environment	1.000	0.823	0.669
Social	0.823	1.000	0.530
Governance	0.669	0.530	1.000

4.2 Impact of the shock on Volkswagen

The results from the Synthetic Control Method (SCM) analysis provide insights into the impact of the Volkswagen (VW) scandal on the stock prices of selected supermarkets. Figure 4.1 illustrates the stock price trajectories of Volkswagen compared to the synthetic control group composed of the largest supermarket companies.

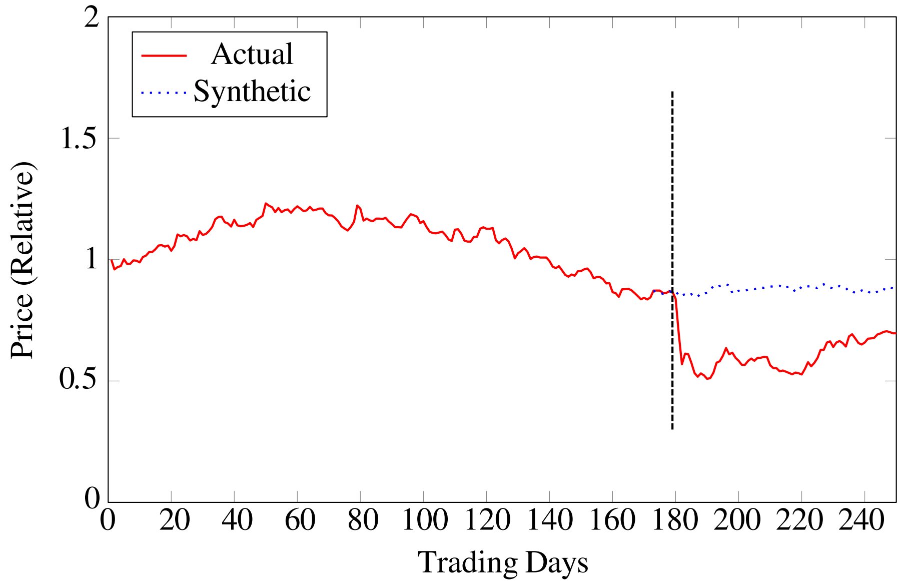


Figure 4.1: Results of the Synthetic Control Method

In the Figure, the black line represents the actual stock prices of Volkswagen, while the grey line denotes the synthetic stock prices derived from the supermarket firms. The vertical dashed line indicates the moment of the scandal, serving as a reference point for evaluating the effects of the event.

Before the scandal, the actual price of Volkswagen closely follows the synthetic control. This indicates that the synthetic control was effective in capturing the trends of the VW stock, allowing for a valid comparison post-event. After the scandal's occurrence, there is a marked decline in Volkswagen's stock price. However, the synthetic control price remains relatively stable and shows no similar decline. This contrast suggests that the scandal did not have spillover effects on the supermarket sector, implying that the reaction of Volkswagen's stock was an isolated event rather than a contagion that impacted other firms in other sectors.

To quantitatively assess these observations, a T-Test was conducted comparing the actual stock prices of Volkswagen after the shock with the synthetic prices. The results are summarized in Table 4.3.

Table 4.3: T-Test Results

Statistic	Value
T-Value	-22.941
Degrees of Freedom	78.922
P-Value	0
Mean Actual	0.629
Mean Synthetic	0.876

The results of the statistical analysis are as follows. The T-value of -22.941 demonstrates a significant difference between the means of the two groups under comparison. The degrees of freedom for the test were 78.922, which aligns with expectations for a relatively large sample size. The P-value is effectively zero, providing strong evidence that the observed difference in means is statistically significant. Comparing the means, the mean actual price of Volkswagen following the shock was0.629, markedly lower than the synthetic mean of 0.876. This substantial disparity underscores the pronounced decline in Volkswagen's stock price relative to its synthetic control.

In conclusion, the analysis indicates that the VW scandal did not trigger spillover effects on the stock prices of the selected supermarket companies. The results suggest that while Volkswagen experienced a significant negative impact, the supermarkets remained largely unaffected. This finding contributes to the understanding of the isolation of the automotive scandal's effects in the context of market responses.

4.3 Regression

4.3.1 Impact of the Shock in Different Regions

The analysis examines the impact of the Dieselgate scandal shock across various regions, specifically differentiating between the entire sample, European automotive companies, and non-European companies. Table 4.4 provides the regression results for the three models, including all data (Model 1), European companies only (Model 2), and non-European companies (Model 3).

In Model 1, which includes all companies, the Treatment variable is negative and statistically significant ($p < 0.01$), indicating a measurable decline in the relative price performance for companies exposed to the shock compared to those unexposed. The interaction term Treatment:Post is also significant at the 10% level, suggesting that the divergence in rela- tive price performance continues to manifest after the shock.

Model 2, focusing exclusively on European companies, reveals a stronger negative effect. The Treatmentvariable increases in magnitude to -0.066 and remains highly significant ($p < 0.01$). Additionally, the Treatment:Postinteraction term shows a much larger differential effect (-0.146), highlighting that European firms were disproportionately affected both during and after the scandal. This finding underscores the heightened vulnerability of European automotive companies, likely due to their geographic proximity to Volkswagen, stricter regulatory environments, and closer market interconnections.

In contrast, Model 3 examines non-European companies and finds no statistically significant effects for either the Treatment variable or the Treatment:Post interaction. This sug- gests that non-European companies were largely insulated from the direct and indirect repercus- sions of the Dieselgate scandal. The smaller magnitude of the coefficients and lack of statistical significance highlight the relative resilience of firms operating outside Europe, likely due to weaker market ties and less exposure to European regulatory pressures.

These results collectively demonstrate that the Dieselgate shock had a geographically uneven impact, with European automotive companies experiencing the most pronounced effects. The stronger spillover effects observed in Europe align with expectations, as firms in closer market proximity to Volkswagen and subject to similar regulatory scrutiny are more likely to experience reputational and market repercussions.

Given the heightened impact on European companies, subsequent analyses will focus primarily on this subgroup to further explore the factors contributing to their increased vulnerability and to assess the role of governance and ESG metrics in mitigating the crisis's effects. The comparison with non-European firms provides valuable context for understanding the regional disparities in shock absorption and resilience.

Table 4.4: Regression Models for Treatment and Post Effects (Models 1, 2, and 3)

	Dependent variable: prccd_relative		
	All Data	Europe Only	Non-Europe Only
	(1)	(2)	(3)
Treatment	−0.037***	−0.066***	−0.021
	(0.014)	(0.021)	(0.016)
Post	−0.003	−0.008	0.000
	(0.014)	(0.021)	(0.016)
Treatment:Post	−0.038*	−0.146***	0.020
	(0.020)	(0.030)	(0.023)
Constant	1.009***	1.128***	0.945***
	(0.010)	(0.015)	(0.011)
Sample	All	Europe Only	Non-Europe Only
Observations	1,200	420	780
R^2	0.032	0.248	0.003
Adjusted R^2	0.030	0.242	−0.001
Residual Std. Error	0.172 (df = 1196)	0.155 (df = 416)	0.160 (df = 776)
F Statistic	13.280*** (df = 3; 1196)	45.706*** (df = 3; 416)	0.864 (df = 3; 776)
Note:			*p<0.1; **p<0.05; ***p<0.01

4.3.2 Impact of Governance on Resilience to the Shock

To assess the role of governance on resilience during the Dieselgate scandal, we included Governanceand its interactions with the Treatmentand Postvariables in Models 4 and 5 (see Table 4.5). Of particular interest is the three-way interaction term with Treatment:Post:Governance, which is highly significant ($p < 0.01$) and positive. This result suggests that companies with higher governance scores were better able to withstand the shock, as indicated by their relatively better performance in the post-shock period.

The positive coefficient of the three-way interaction term implies that strong governance frameworks can act as a buffer during crises. Specifically, companies with better governance are less affected by reputational shocks like the Dieselgate scandal, underscoring the protective role governance can play in times of crisis. Model 5, which excludes Volkswagen, reinforces this finding, showing similar significance levels and coefficient values, indicating the robustness of the governance effect even when the shock's direct source is removed from the analysis.

These findings support the hypothesis that good governance contributes to resilience, providing a stabilizing effect on company performance when facing adverse events. Governance, therefore, emerges as a key factor in mitigating the negative impacts of sector-wide reputational crises.

Table 4.5: Regression Models for Treatment and Post Effects with Governance (Models 4 and 5)

	Dependent variab e: prccd_relative	
	Governance	Governance
	(4)	(5)
Treatment	−0.210***	−0.199***
	(0.064)	(0.055)
Post	−0.010	−0.011
	(0.064)	(0.055)
Governance	−0.002	−0.001
	(0.005)	(0.004)
Treatment:Post	−0.390***	−0375***
	(0.007)	(0.006)
Treatment:Post:Governance	0.028***	0.029***
	(0.010)	(0.009)
Constant	1.146***	1.158***
	(0.045)	(0.039)
Sample	Europe Only	Europe w/o VW
Observations	420	360
R^2	0.377	0.421
Adjusted R^2	0.366	0.410
Residual Std. Error	0.142 (df = 412)	0.122 (df = 352)
F Statistic	35.553*** (df = 7; 412)	36.613*** (df = 7; 352)
Note:		*p<0.1; **p<0.05; ***p<0.01

If we take a look at the Figure 4.2, we see, as expected from the regression, a significant difference between two groups with a good G score of 10, or A-, and companies with a poorer score. We can see that after three weeks, companies have roughly reached their pre-shock level again, while the weaker companies have not.

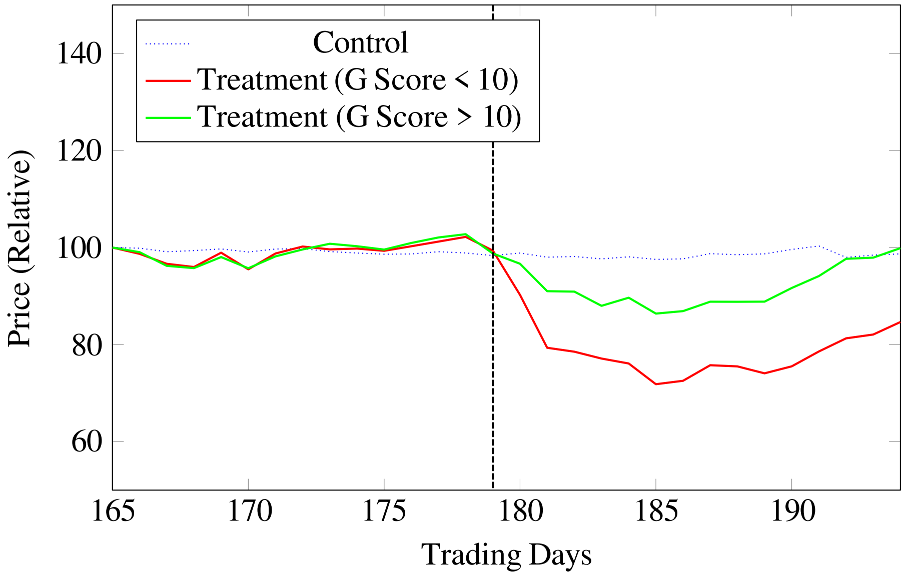


Figure 4.2: Indexed Average Relative Price by Trading Day for Treatment and Control Groups (Sample: Europe w/o VW)

If we further reduce the data set to exclude Porsche due to high dependency and ownership, the coefficients remain comparable and the shock is slightly significant with a ($p < 0.1$), but the triple interaction term is no longer significant. The probability of a type 1 error is 14 % (6.5).

4.3.3 Impact of Environmental and Social on Resilience to the Shock

Based on the findings in previous sections, this chapter extends the analysis by examining the impact of Environmental and Social scores on resilience to the Dieselgate scandal within the European automotive sector. Using Models 6 and 7, as presented in Table 4.6, the study focuses on Environmental and Social factors to evaluate whether they similarly mitigate the adverse effects of a reputational shock.

In Model 6, which incorporates Environmental scores, the three-way interaction term is statistically significant ($p < 0.01$) and positive. This suggests that higher environmental ratings are associated with a greater resilience to the Dieselgate shock, similar to the findings related to governance in prior models. Specifically, the positive interaction term implies that companies with stronger environmental practices might experience less pronounced declines in relative price performance following a reputational crisis, possibly due to perceived long-term sustainability and responsibility by investors and stakeholders.

Similarly, Model 7 analyzes the role of Social scores and reveals a comparable effect. The Treatment:Post:Social interaction term is also positive and significant ($p < 0.01$), rein- forcing the notion that companies with higher social ratings—such as strong labor practices and community involvement—tend to be more resilient in times of reputational crisis. This positive association implies that such firms might benefit from a perception of ethical and responsible practices, which can provide a cushion against adverse impacts from sector-wide reputational shocks.

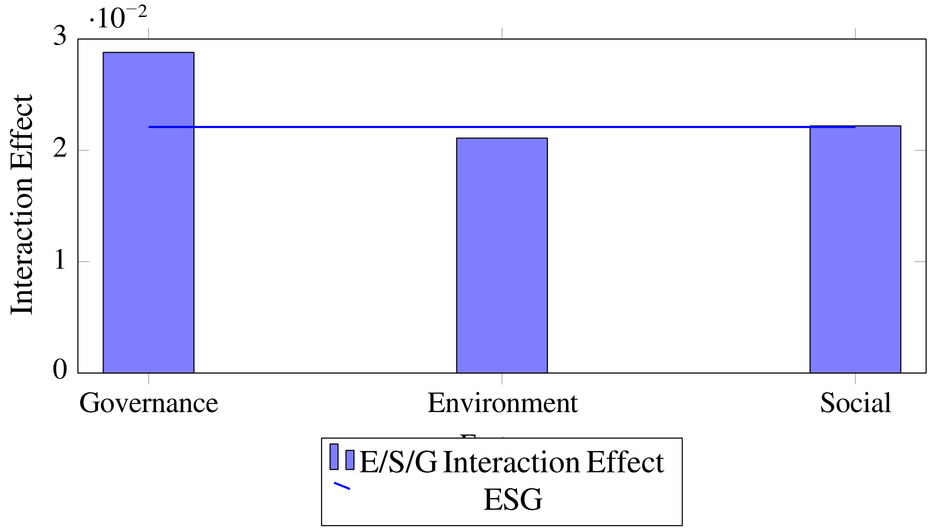
Both Environmental and Social scores, therefore, emerge as valuable predictors of resilience, supporting the hypothesis that broader ESG factors contribute positively to firm stability under reputational pressure. The results underscore the importance of a comprehensive ESG strategy, as companies with robust Environmental and Social commitments appear better equipped to withstand the financial repercussions of reputational challenges, much like those with strong governance practices observed in Models 3 and 4.

Table 4.6: Regression Models for Environmental and Social Scores (Models 6 and 7)

	Dependent variable: Price	
	Environment	Social
	(6)	(7)
Treatment	-0.225^{***}	-0.282^{***}
	(0.045)	(0.047)
Post	-0.010	-0.010
	(0.045)	(0.047)
Environment	0.0003	
	(0.003)	
Social		0.0004
		(0.003)
Treatment:Post	-0.332^{***}	-0.333^{***}
	(0.064)	(0.067)
Treatment:Post:Environment	0.0211^{***}	
	(0.006)	
Treatment:Post:Social		0.0222^{**}
		(0.007)
Constant	1.143^{***}	1.142^{***}
	(0.032)	(0.033)
Sample	Europe w/o VW	Europe w/o VW
Observations	360	360
R^2	0.507	0.546
Adjusted R^2	0.497	0.537
Residual Std. Error	0.113 (df = 352)	0.108 (df = 352)
F Statistic	51.64^{***} (df = 7; 352)	60.56^{***} (df = 7; 352)
Note:		*p<0.1; **p<0.05; ***p<0.01

In addition, a table in the appendix provides a comparative overview of Governance, Environment, Social, and overall ESG scores (see Table 6.6). The similarity in results across these ESG pillars aligns with expectations, as discussed in the chapter on multicollinearity. This consistency across pillars reinforces the notion that companies with higher scores in any of these dimensions demonstrate a comparable resilience to reputational shocks, likely due to overlapping attributes among the ESG pillars. The anticipated multicollinearity, as previously examined, suggests that while each pillar independently signals resilience, they also collectively reflect a broader, interrelated ESG framework that contributes to stability in times of crisis. As Figure 4.3 shows, the governance factor has the strongest effect (0.0288), indicating that governance plays a crucial role in mitigating reputational shocks and maintaining stock price stability in the aftermath of the shock. By comparison, the environmental (0.0211) and social (0.0222) factors show slightly lower effects, although they are still significant. This is consistent with the prediction of hypothesis 2, where governance acts as a stronger signal and a more effective strategically fitting resource against such a shock.

Figure 4.3: Interaction Effects of Governance, Environment, Social, and ESG Scores



4.3.4 Control Variables and Fixed Effects

The inclusion of control variables and fixed effects in the regression models provides a deeper understanding of the factors contributing to resilience in the European automotive sector during the Dieselgate scandal. Table 4.7 presents an excerpt of Model 9, where control variables such as revenue (revt), EBITDA ratio (ebitda.teq), current assets-to-liabilities (act.lct), and cash-to-liabilities ratio (che.lct) were added to assess their impact. Notably, the co- efficient for the ebitda.teq variable is significant and negative, a result contrary to initial expectations, as a higher EBITDA ratio would typically be anticipated to positively correlate with resilience. Instead, this unexpected negative coefficient may suggest that companies with high EBITDA ratios faced challenges in maintaining resilience under the reputational pressure of the Dieselgate crisis, possibly due to higher exposure or reduced flexibility in adjusting to shocks.

It is essential to highlight that the interaction term Treatment:Post:Governance re- mains statistically significant throughout Models 9, 10, and 11, even when control variables and fixed effects are included. This persistence of significance underscores the robustness of governance as a key factor in explaining resilience to reputational shocks. Despite the added complexity from control variables and the adjustment for unobserved heterogeneity through fixed effects, the positive and significant interaction term indicates that companies with stronger governance frameworks experience better relative performance in the aftermath of the Dieselgate scandal.

It is also worth noting that the observed effects of the control variables may be influenced by the relatively small size of the target group in the analysis. This reduced sample size could potentially affect the stability and generalizability of these estimates, and thus, these findings should be interpreted with caution.

In terms of model fit, Model 8 demonstrates a high R^2 of 0.826, and an adjusted R^2 of 0.821, suggesting that the model explains a substantial portion of the variance in relative stock price performance among European companies without Volkswagen. This high R^2 value indicates the model's robustness and its capacity to account for resilience factors during the crisis.

Table 4.7: Effects of Control Variables on Price (Model 9)

Variable	**Estimate**	**Std. Error**
Size (revt)	-0.000005^{***}	(0.000001)
Profitability (ebitda.teq)	-2.076^{***}	(0.150)
Current Ratio (act.lct)	6.279^{***}	(0.689)
Liquidity Ratio (che.lct)	-6.321^{***}	(0.661)

Table 4.8 provides insights from Models 9, 10 and 11, which incorporate fixed effects (FE) along with control variables in Model 11. Model 10 uses fixed effects for companies and time (Trading.Day) but excludes specific control variables, achieving an R^2 of 0.840. This strong model fit implies that the fixed effects capture significant unobserved heterogeneity across companies and time periods, enhancing explanatory power.

In Model 10, control variables were added alongside fixed effects. Notably, all coefficients for Company fixed effects returned NA values, suggesting that the individual company characteristics were already fully accounted for by other variables in the model, particularly the governance measures and control variables. This further indicates that company-specific resilience factors, such as revenue or liquidity, are comprehensively reflected in the control variables, reducing the need for explicit company-level fixed effects in this context. The R^2 and adjusted R^2 values remain consistent between Models 10 and 11 at 0.840 and 0.820, respectively, reinforcing the robustness of the model without requiring additional control variables.

In summary, the results underscore the importance of governance and financial control variables in explaining resilience to the Dieselgate shock, with fixed effects capturing additional unobserved factors, as indicated by the high R^2 values. The continued significance of the governance interaction term highlights governance as a critical resilience factor, even when accounting for various controls and fixed effects. Nonetheless, given the small target group size, caution is warranted when interpreting these findings, as sample limitations may affect the reliability of control variable estimates.

Table 4.8: Regression Models with and without Fixed Effects and Control Variables (Models 9, 10, and 11)

	Dependent variable: Price		
	Model 8	Model 9	Model 10
	Governance	Governance	Governance
Treatment	−0.199***	−0.199***	−0.199***
	(0.030)	(0.030)	(0.030)
Post	−0.011	0.021	0.021
	(0.030)	(0.040)	(0.040)
Governance	−0.295***	−0.264***	−0.295***
	(0.021)	(0.013)	(0.021)
Treatment:Post	−0.375***	−0.375***	−0.375***
	(0.043)	(0.043)	(0.043)
Treatment:Governance	0.017***	0.017***	0.017***
	(0.003)	(0.003)	(0.003)
Post:Governance	0.0002	0.0002	0.0002
	(0.003)	(0.003)	(0.003)
Treatment:Post:Governance	0.029***	0.029***	0.029***
	(0.005)	(0.005)	(0.005)
Constant	−0.032	3.712***	−0.023
	(0.296)	(0.120)	(0.297)
Control Variables	Yes	No	Yes
Fixed Effects (FE)	No	Yes	Yes
Sample	Europe w/o VW	Europe w/o VW	Europe w/o VW
Observations	360	360	360
R^2	0.826	0.840	0.840
Adjusted R^2	0.821	0.820	0.820
Residual Std. Error	0.068 (df = 348)	0.068 (df = 320)	0.068 (df = 320)
F Statistic	150.30*** (df = 11; 348)	43.03*** (df = 39; 320)	43.03*** (df = 39; 320)

Note: *p<0.1; **p<0.05; ***p<0.01

4.3.5 Model Validation and Robustness

Table 4.9: Diagnostic Test Results for All Models

Test	Result (Range)
Breusch-Pagan Test (p-value)	1.70×10^{-10} to $< 2.2 \times 10^{-16}$
Breusch-Godfrey Test (p-value)	$< 2.2 \times 10^{-16}$
RESET Test (p-value)	$< 2.2 \times 10^{-16}$ to 1.0
Shapiro-Wilk Test (p-value)	7.82×10^{-4} to 1.34×10^{-13}
VIF (Range)	2.0 to 64394.24

The results of the diagnostic tests provide valuable insights into the assumptions and limitations of the applied models.

The Breusch-Pagan test (Breusch and Pagan, 1979) checks for heteroskedasticity, i.e., whether the residual variance remains constant. Significant p-values in all models indicate the presence of heteroskedasticity. To address this issue, cluster-robust standard errors were used (Angrist and Pischke, 2009), ensuring that the estimated standard errors are robust to heterogenous variances.

The Breusch-Godfrey test (Breusch, 1978; Godfrey, 1978) assesses autocorrelation in the residuals, which is particularly relevant for panel data where observations within a firm or over time may be correlated. Cluster-robust standard errors also account for these dependencies and were implemented accordingly.

The Ramsey RESET test (Ramsey, 1969) examines specification errors, such as omitted non-linear relationships. The significant p-values ($p < 2.2 \times 10^{-16}$) in some models were expected, as a simple linear model was deliberately chosen. Previous visualizations suggested non-linear patterns, but a linear model was preferred for simplicity and interpretability. This limitation is addressed in the discussion.

The Shapiro-Wilk test (Shapiro and Wilk, 1965) examines the normality of residuals. The p-values (7.82×10^{-4} to 1.34×10^{-13}) show that residuals are not normally distributed in most models. This is common for large datasets (Gelman and Hill, 2007) and minimally affects estimator performance as robust standard errors were used.

VIF values (Variance Inflation Factor, Marquardt, 1970) range from 2.0 to extremely high values (64394.24), especially in models with interaction terms. This was expected, as interaction effects often introduce strong multicollinearity (Kutner et al., 2004). Despite high VIF values, coefficient interpretation remains valid as the multicollinearity stems from the data structure rather than redundant variables.

The analysis incorporates both company-clustered and day-clustered standard errors to ensure that results are robust to different dependency structures. Table 4.10 presents the estimated coefficients and associated standard errors for both clustering approaches, exemplified by Model 9.

Company-clustered standard errors account for dependencies within individual firms, which

Table 4.10: Regression Coefficients with Company- and Day-clustered Standard Errors for Model 9

Variable	Estimate	Company-clustered SE	Day-clustered SE
Intercept	3.7115	0.0341	0.0557
Treatment	-0.1989	0.0685	0.0036
Post	0.0208	0.0081	0.0074
Governance	-0.2642	0.0037	0.0059
Treatment:Post	-0.3752	0.0090	0.0175
Treatment:Governance	0.0171	0.0080	0.0005
Treatment:Post:Governance	0.0288	0.0019	0.0016

may arise from firm-specific characteristics like governance. This approach is particularly relevant when analyzing variables that vary across firms but remain constant within a firm. In contrast, day-clustered standard errors control for correlations between all firms on a specific trading day, often caused by external shocks like macroeconomic events.

The results indicate that the estimated coefficients remain stable regardless of the clustering approach. With day-clustered standard errors, estimates for some variables, such as 'Treatment', are more conservative, reflecting stricter control for market-wide dependencies. Using both clustering methods ensures that the models account for both firm-specific and temporal dependencies.

Overall, the significant effects, particularly the interaction term 'Treatment:Post:Governance', remain consistent across both approaches. This confirms that governance values mitigate the negative effects of the treatment in the post-shock period. Employing both clustering approaches thus provides comprehensive validation of the results and underscores the robustness of the models.

5 Discussion

5.1 Contributions to Resilience and ESG Literature

This thesis set out to investigate whether ESG, and particularly governance, serves as a shield against reputational shocks caused by peer misconduct, using the Dieselgate scandal in the automotive sector as a case study. By analyzing stock price reactions with a combination of the Synthetic Control Method (SCM) and Difference-in-Differences (DiD), based on data from Compustat and Refinitiv, the study found that governance had the most significant protective effect. Firms with stronger governance demonstrated greater resilience to the spillover effects of Dieselgate, while ESG as a broader concept supported overall stability.

The findings of this thesis provide significant contributions to the understanding of how ESG framework shields firms from reputational harm caused by the misconduct of peer companies. By focusing on the Dieselgate scandal, this study tests hypotheses: (1) ESG acts as a shield against peer-originated shocks, and (2) governance, as a strategic fit, has the strongest effect during governance related crises.

First, the results strongly support the hypothesis that ESG factors, particularly governance, play a critical protective role in reputational crises driven by the actions of other firms. The concept of "lost without deserving," as described by Jonsson (2001), is evident in this analysis. Non-culpable firms in the automotive sector suffered significant stock price declines following the Dieselgate scandal, not because of direct misconduct, but due to market-wide perceptions of governance risks. However, firms with stronger governance structures demonstrated greater resilience, experiencing less severe stock price impacts. This highlights the importance of governance as a shield, not just for a firm's own actions, but also for mitigating the reputational fallout caused by misconduct elsewhere in the industry.

This finding extends the literature on resilience and market dynamics by showing that strong governance not only mitigates firm-specific risks but also insulates against the spillover effects of peer actions. Unlike prior studies on ESG and resilience during crises such as the COVID-19 pandemic (Albuquerque et al., 2020) or the 2008 financial crisis (DesJardine et al., 2019), this thesis identifies governance as uniquely positioned to address reputational shocks triggered by external, peer-driven events.

Second, the analysis suggests a strategic fit between governance capabilities and the specific nature of reputational risks. Governance emerged as the most influential ESG pillar, offering the strongest protection during the Dieselgate scandal. This finding aligns with the Resource-

Based View (RBV) (Barney, 1991) and Stakeholder Theory (Freeman, 1984), demonstrating that governance resources and effective stakeholder management are critical for firms to withstand external shocks. While ESG has been broadly linked to resilience in previous studies, this thesis isolates governance as the key driver of resilience during peer-originated reputational crises, providing a novel contribution to the literature.

Furthermore, this study confirms the rapid incorporation of reputational risks into stock prices, consistent with Efficient Market Theory (Fama, 1970). Market participants reacted not only to Volkswagen's actions but also to perceived governance weaknesses across the entire automotive sector. Firms with strong governance, however, were able to counteract this market stigma, underscoring the critical role of governance in protecting firms from both direct and indirect reputational harm.

Overall, this thesis advances the understanding of ESG, and particularly governance, as a strategic asset in reputational risk management. By demonstrating that governance serves as a shield against peer-originated shocks, it highlights a novel mechanism through which ESG contributes to resilience. While the limited dataset constrains the generalizability of these findings, they complement and extend existing literature by identifying governance as a decisive factor in mitigating the reputational fallout from industry-wide scandals.

5.2 Limitations

This study acknowledges several key limitations that may affect the interpretation and generalizability of its findings. While the results are statistically significant, they must be understood within the constraints of the study's design.

First, the Synthetic Control Method (SCM) relies on the assumption that the synthetic control group mirrors the treatment group in pre-treatment characteristics. Using supermarkets as the synthetic control group, while pragmatic, may not fully capture the unique dynamics of the automotive sector. Additionally, the synth package in R, commonly applied outside of capital markets research, differs from standard finance models such as those proposed by Fama and French (1993) and Sharpe (1964). To address this limitation, future research could explore sector-specific control groups or combine SCM with traditional financial asset-pricing frameworks to enhance robustness.

Second, the generalizability of this study is limited by its focus on the top 20 global automotive manufacturers. This selection excludes mid-sized or emerging companies that may exhibit different resilience dynamics. Furthermore, the exclusion of Volkswagen, while necessary to mitigate the influence of an extreme outlier, might understate the broader impact of the Dieselgate scandal on the automotive sector. Expanding the dataset to include a more diverse range of companies could address these concerns in future research. This aligns with broader discussions in resilience literature, which emphasize the importance of defining "resilience of what to what" (Carpenter et al., 2001), highlighting the need to capture diverse contexts and shocks for a comprehensive understanding.

Third, the variability of ESG scores across different providers introduces challenges. This study utilized Refinitiv ESG scores, which may differ significantly from those provided by other rating agencies such as MSCI or Sustainalytics (Berg et al., 2022). To improve comparability, future studies could incorporate multiple ESG providers or harmonize scores across methodologies to mitigate provider-specific biases.

Finally, disentangling the effect of ESG factors on resilience from the direct impact of the Dieselgate shock remains a key methodological challenge. Companies with high ESG scores might not have been more resilient but simply less exposed to the shock's intensity—a phenomenon referred to as a "heterogeneous treatment effect." Future research could address this by incorporating interaction models that account for varying levels of shock exposure or by using qualitative case studies to complement quantitative findings.

5.3 Future Research Directions

The findings of this thesis open avenues for future research that could extend the scope and depth of resilience studies in the context of reputational shocks. Broadening the dataset to include small and medium-sized enterprises (SMEs) or firms from emerging markets could offer insights into how company size or regional context influences resilience. Additionally, investigating diverse types of reputational crises—such as HM's greenwashing controversy, Carlos Ghosn's arrest, or the Deepwater Horizon oil spill—could uncover variations in ESG and governance impacts across industries and crisis types.

Future research could also explore advanced econometric techniques. Non-linear models, such as quantile regressions, may capture differential impacts of ESG factors at varying performance levels, while machine learning methods, including random forests or gradient boosting, could identify complex interactions between variables. Furthermore, network analysis could reveal interdependencies and spillover effects among firms during crises, offering a richer understanding of reputational contagion.

Expanding the temporal scope and metrics used in analysis could also enhance insights. Shifting from short-term stock price movements to longer-term financial and operational metrics, such as sales, market share, or profitability, could provide a more comprehensive view of resilience. Additionally, analyzing organizational recovery metrics, such as time to pre-crisis performance levels or shifts in consumer sentiment, could further clarify how companies respond to reputational crises.

Incorporating qualitative methods, such as case studies or interviews, could complement quantitative findings by providing deeper insights into internal decision-making processes during crises. This approach could shed light on how firms operationalize ESG principles and adapt governance practices to manage shocks effectively.

Finally, future studies could investigate the long-term effects of reputational crises, examining whether ESG-driven resilience translates into sustained competitive advantages. Metrics such as long-term stock performance, strategic repositioning, or changes in stakeholder trust could be explored to evaluate the enduring impact of ESG and governance on resilience.

6 Conclusion

In this thesis, we explored the resilience of firms within the automotive sector in response to reputational shocks, particularly examining the impact of ESG and governance factors. The findings contribute to an understanding of how firms navigate crises triggered by industry-wide scandals, reinforcing that companies with strong governance and stakeholder management practices are better equipped to endure such reputational challenges. By aligning with the Resource-Based View (RBV) and Stakeholder Theory, this research emphasizes the role of governance as a unique and valuable asset that aids in preserving firm stability and trust during crises.

Shakespeare's reflection on reputation in *Othello*—"Reputation is an idle and most false imposition, often got without merit and lost without deserving"—is a poignant reminder of the volatile nature of public perception. Like Othello, who falls prey to the manipulations of Iago, firms in this study suffer from reputational damage that they did not necessarily earn. The "lost without deserving" phenomenon, as observed in prior literature (Jonsson, 2001), surfaces repeatedly in modern markets, as companies are judged not solely on their actions but also on their association with broader industry or societal issues.

The thesis provides empirical evidence that governance and ESG factors, particularly those related to governance, offer some protection against the fallout from reputational shocks. However, these protections are not absolute; the market, as suggested by Efficient Market Theory (Fama, 1970), swiftly incorporates negative reputational information, penalizing firms even when they have minimal direct involvement. This underscores the need for firms to cultivate not only strong internal resources but also proactive reputational risk management practices to mitigate the impact of such collective market judgments.

Despite significant insights, the study acknowledges certain limitations. Data constraints and methodological choices, such as reliance on OLS regression without nonlinear models, leave room for further exploration into the complexities of resilience. Additionally, issues of multicollinearity among ESG dimensions, as noted by Berg et al. (2022), highlight the challenge of interpreting isolated ESG factors within resilience frameworks.

Looking forward, future research should broaden the scope to incorporate a wider variety of crises across different sectors, allowing for a deeper understanding of how resilience mechanisms operate in diverse contexts. The inclusion of non-linear econometric models or machine learning approaches could yield more robust insights into resilience dynamics, especially in complex scenarios where traditional linear models may fall short. Expanding beyond the automotive industry to examine cases like the H&M greenwashing incident or the Deepwater

Horizon spill could enrich the field's understanding of reputational resilience across various ESG-related controversies.

In conclusion, while reputation may indeed be an "idle and most false imposition," as Shakespeare's quote in the beginning of this thesis poignantly suggests, it holds significant, tangible consequences in today's capital markets. Firms that recognize and proactively manage this "false imposition" through robust governance and strong ESG practices can better position themselves to withstand the storms of public perception. Through continued refinement of resilience strategies and governance structures, companies can not only endure reputational challenges but also emerge more resilient and respected in the face of adversity.

Appendix

Table 6.1: Correlations of Automotive Companies before the Diesel Scandal

			Europe										***Non-Europe***							
	VW	BMW	MBG	POR	REN	STE	VOL	BYD	FORD	GM	HON	HYU	KIA	MAZ	NIS	SAIC	SUZ	TATA	TSLA	TOY
VW	1.00	0.55	0.51	0.73	0.76	0.60	0.58	0.41	0.07	0.27	0.49	0.05	0.16	0.38	0.22	-0.32	0.32	0.82	0.25	0.34
BMW	0.55	1.00	0.95	0.66	0.77	0.93	-0.11	0.93	0.60	0.91	0.54	0.78	0.84	-0.16	0.65	-0.14	-0.27	0.80	0.81	0.26
MBG	0.51	0.95	1.00	0.62	0.71	0.87	-0.05	0.86	0.63	0.94	0.43	0.71	0.79	-0.25	0.53	-0.05	-0.40	0.80	0.78	0.13
POR	0.73	0.66	0.62	1.00	0.84	0.70	0.57	0.53	0.37	0.45	0.71	0.22	0.30	0.30	0.17	-0.16	0.33	0.78	0.49	0.61
REN	0.76	0.77	0.71	0.84	1.00	0.86	0.37	0.73	0.61	0.61	0.81	0.43	0.50	0.44	0.56	-0.17	0.23	0.85	0.70	0.43
STE	0.60	0.93	0.87	0.70	0.86	1.00	0.03	0.89	0.62	0.82	0.56	0.69	0.73	0.05	0.70	-0.22	-0.11	0.83	0.81	0.34
VOL	0.58	-0.11	-0.05	0.57	0.37	0.03	1.00	-0.26	-0.14	-0.26	0.31	-0.52	-0.43	0.60	-0.37	-0.13	0.63	0.40	-0.20	0.37
BYD	0.41	0.93	0.86	0.53	0.73	0.89	-0.26	1.00	0.67	0.88	0.61	0.86	0.86	-0.07	0.80	-0.14	-0.25	0.70	0.90	0.28
FORD	0.07	0.60	0.63	0.37	0.61	0.62	-0.14	0.67	1.00	0.77	0.62	0.69	0.75	0.04	0.53	0.40	-0.22	0.37	0.84	0.02
GM	0.27	0.91	0.94	0.45	0.61	0.82	-0.26	0.88	0.77	1.00	0.44	0.84	0.91	-0.30	0.63	0.12	-0.46	0.65	0.90	0.04
HON	0.49	0.54	0.43	0.71	0.81	0.56	0.31	0.61	0.62	0.44	1.00	0.41	0.46	0.52	0.49	0.02	0.43	0.56	0.65	0.47
HYU	0.05	0.78	0.71	0.22	0.43	0.69	-0.52	0.86	0.69	0.84	0.41	1.00	0.95	-0.38	0.73	0.16	-0.48	0.39	0.84	0.17
KIA	0.16	0.84	0.79	0.30	0.50	0.73	-0.43	0.86	0.75	0.91	0.46	0.95	1.00	-0.37	0.67	0.25	-0.48	0.49	0.86	0.08
MAZ	0.38	-0.16	-0.25	0.30	0.44	0.05	0.60	-0.07	0.04	-0.30	0.52	-0.38	-0.37	1.00	0.14	-0.32	0.84	0.19	-0.01	0.22
NIS	0.22	0.65	0.53	0.17	0.56	0.70	-0.37	0.80	0.53	0.63	0.49	0.73	0.67	0.14	1.00	-0.33	-0.07	0.39	0.72	0.06
SAIC	-0.32	-0.14	-0.05	-0.16	-0.17	-0.22	-0.13	-0.14	0.40	0.12	0.02	0.16	0.25	-0.32	-0.33	1.00	-0.34	-0.22	0.14	-0.16
SUZ	0.32	-0.27	-0.40	0.33	0.23	-0.11	0.63	-0.25	-0.22	-0.46	0.43	-0.48	-0.48	0.84	-0.07	-0.34	1.00	0.04	-0.18	0.42
TATA	0.82	0.80	0.80	0.78	0.85	0.83	0.40	0.70	0.37	0.65	0.56	0.39	0.49	0.19	0.39	-0.22	0.04	1.00	0.62	0.40
TSLA	0.25	0.81	0.78	0.49	0.70	0.81	-0.20	0.90	0.84	0.90	0.65	0.84	0.86	-0.01	0.72	0.14	-0.18	0.62	1.00	0.29
TOY	0.34	0.26	0.13	0.61	0.43	0.34	0.37	0.28	0.02	0.04	0.47	0.17	0.08	0.22	0.06	-0.16	0.42	0.40	0.29	1.00

Table 6.2: Correlations of Automotive Companies after the Diesel Scandal

	Europe							*Non-Europe*												
	VW	BMW	MBG	POR	REN	STE	VOL	BYD	FORD	GM	HON	HYU	KIA	MAZ	NIS	SAIC	SUZ	TATA	TSLA	TOY
VW	1.0	0.55	0.65	0.95	0.61	0.68	0.68	-0.21	0.47	0.17	0.64	-0.62	-0.41	0.37	0.21	0.48	0.75	0.52	0.12	0.36
BMW	0.55	1.0	0.97	0.44	0.97	0.92	0.88	0.61	0.93	0.84	0.88	-0.19	-0.04	0.9	0.83	0.75	0.74	0.95	-0.62	0.86
MBG	0.65	0.97	1.0	0.53	0.98	0.95	0.89	0.55	0.95	0.83	0.91	-0.28	-0.11	0.88	0.84	0.79	0.75	0.97	-0.56	0.85
POR	0.95	0.44	0.53	1.0	0.49	0.63	0.6	-0.37	0.33	0.02	0.48	-0.56	-0.39	0.19	0.05	0.43	0.63	0.37	0.31	0.23
REN	0.61	0.97	0.98	0.49	1.0	0.93	0.85	0.57	0.94	0.83	0.92	-0.24	-0.11	0.87	0.82	0.75	0.76	0.96	-0.59	0.84
STE	0.68	0.92	0.95	0.63	0.93	1.0	0.88	0.41	0.89	0.75	0.8	-0.21	0.0	0.8	0.69	0.8	0.75	0.89	-0.39	0.81
VOL	0.68	0.88	0.89	0.6	0.85	0.88	1.0	0.33	0.84	0.67	0.76	-0.43	-0.23	0.8	0.66	0.66	0.76	0.88	-0.29	0.85
BYD	-0.21	0.61	0.55	-0.37	0.57	0.41	0.33	1.0	0.69	0.88	0.45	0.22	0.22	0.68	0.79	0.33	0.11	0.65	-0.85	0.65
FORD	0.47	0.93	0.95	0.33	0.94	0.89	0.84	0.69	1.0	0.94	0.85	-0.11	0.06	0.92	0.91	0.79	0.68	0.98	-0.62	0.92
GM	0.17	0.84	0.83	0.02	0.83	0.75	0.67	0.88	0.94	1.0	0.72	0.07	0.19	0.89	0.92	0.65	0.46	0.9	-0.75	0.89
HON	0.64	0.88	0.91	0.48	0.92	0.8	0.76	0.45	0.85	0.72	1.0	-0.22	-0.12	0.84	0.81	0.72	0.81	0.89	-0.6	0.79
HYU	-0.62	-0.19	-0.28	-0.56	-0.24	-0.21	-0.43	0.22	-0.11	0.07	-0.22	1.0	0.89	-0.01	0.03	0.08	-0.23	-0.24	-0.26	-0.09
KIA	-0.41	-0.04	-0.11	-0.39	-0.11	0.0	-0.23	0.22	0.06	0.19	-0.12	0.89	1.0	0.14	0.13	0.32	-0.04	-0.09	-0.24	0.03
MAZ	0.37	0.9	0.88	0.19	0.87	0.8	0.8	0.68	0.92	0.89	0.84	-0.01	0.14	1.0	0.89	0.78	0.75	0.91	-0.73	0.91
NIS	0.21	0.83	0.84	0.05	0.82	0.69	0.66	0.79	0.91	0.92	0.81	0.03	0.13	0.89	1.0	0.74	0.5	0.9	-0.78	0.83
SAIC	0.48	0.75	0.79	0.43	0.75	0.8	0.66	0.33	0.79	0.65	0.72	0.08	0.32	0.78	0.74	1.0	0.72	0.75	-0.45	0.66
SUZ	0.75	0.74	0.75	0.63	0.76	0.75	0.76	0.11	0.68	0.46	0.81	-0.23	-0.04	0.75	0.5	0.72	1.0	0.69	-0.27	0.66
TATA	0.52	0.95	0.97	0.37	0.96	0.89	0.88	0.65	0.98	0.9	0.89	-0.24	-0.09	0.91	0.9	0.75	0.69	1.0	-0.62	0.91
TSLA	0.12	-0.62	-0.56	0.31	-0.59	-0.39	-0.29	-0.85	-0.62	-0.75	-0.6	-0.26	-0.24	-0.73	-0.78	-0.45	-0.27	-0.62	1.0	-0.56
TOY	0.36	0.86	0.85	0.23	0.84	0.81	0.85	0.65	0.92	0.89	0.79	-0.09	0.03	0.91	0.83	0.66	0.66	0.91	-0.56	1.0

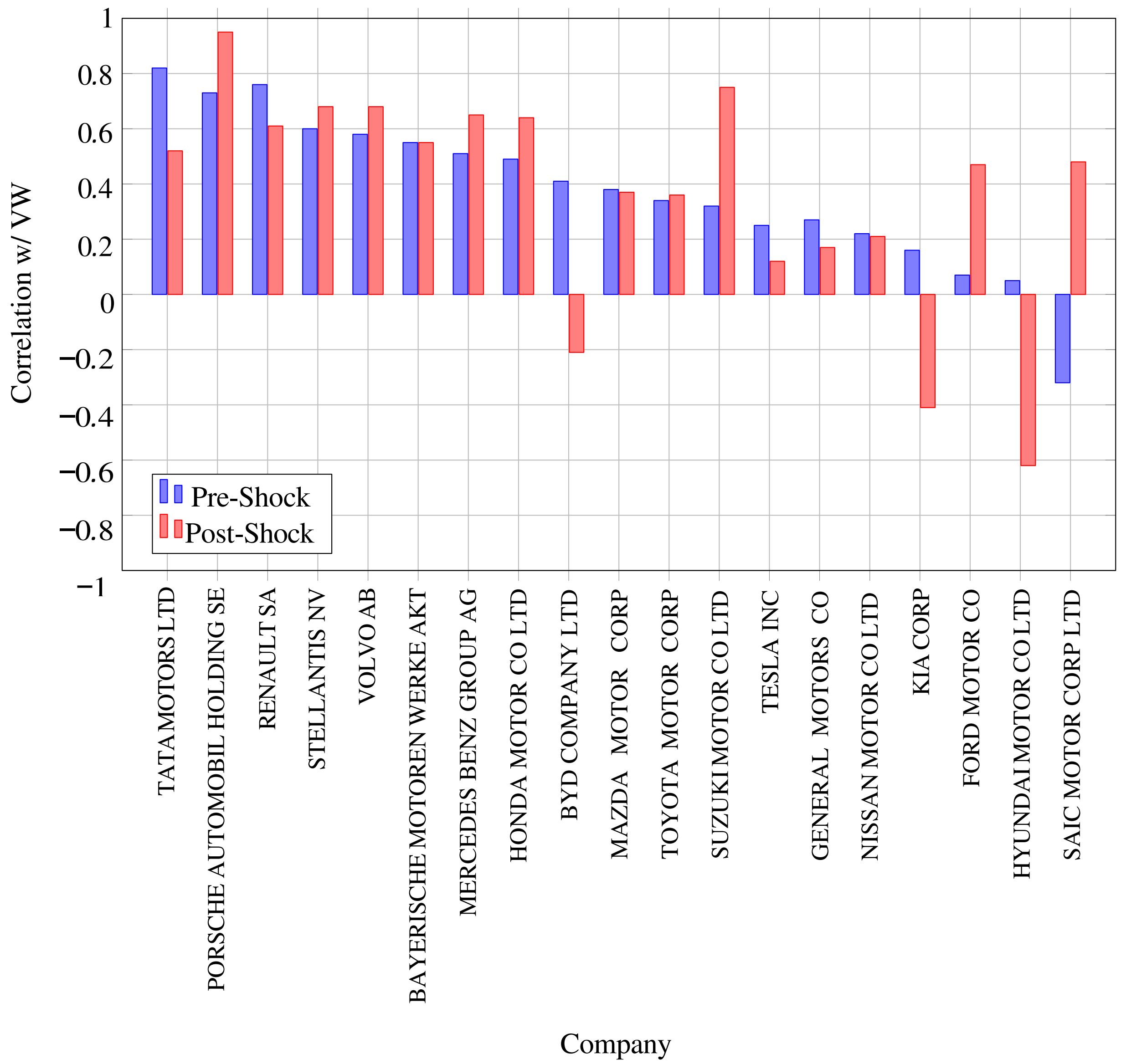


Figure 6.1: Correlation with Volkswagen for Various Companies Before and After Shock

Table 6.3: Correlations of Supermarkets before the Diesel Scandal

	Carrefour	Costco	Ahol d Delhaize	Target	Tesco	\ lmart
Carrefour	1.00	0.98	0.90	0.87	0.90	0.88
Costco	0.98	1.00	0.92	0.91	0.92	0.89
Ahold Delhaize	0.90	0.92	1.00	0.94	0.96	0.94
Target	0.87	0.91	0.94	1.00	0.94	0.95
Tesco	0.90	0.92	0.96	0.94	1.00	0.94
Walmart	0.88	0.89	0.94	0.95	0.94	1.00

Table 6.4: Correlations of Supermarkets after the Diesel Scandal

	Carrefour	Costco	Ahol d Delhaize	Target	Tesco	\ lmart
Carrefour	1.00	0.99	0.94	0.88	0.94	0.92
Costco	0.99	1.00	0.94	0.92	0.94	0.93
Ahold Delhaize	0.94	0.94	1.00	0.91	0.97	0.94
Target	0.88	0.92	0.91	1.00	0.90	0.94
Tesco	0.94	0.94	0.97	0.90	1.00	0.93
Walmart	0.92	0.93	0.94	0.94	0.93	1.00

Table 6.5: Regression Model with Governance w/o VW & Porsche

	Estimate	Std. Error	t value	$Pr(>\|t\|)$
(Intercept)	1.870657	0.144350	12.959	$< 2e-16$***
Treatment	1.427379	0.204141	6.992	$1.85e-11$***
Post	-0.055411	0.204141	-0.271	0.7862
Governance	-0.072330	0.014406	-5.021	$8.97e-07$***
Treatment:Post	-0.511177	0.288699	-1.771	0.0777·
Treatment:Governance	-0.144673	0.020373	-7.101	$9.46e-12$***
Post:Governance	0.004593	0.020373	0.225	0.8218
Treatment:Post:Governance	0.042346	0.028812	1.470	0.1427

Note: ***p<0.01; **p<0.05; *p<0.1; ·p<0.1

Table 6.6: Regression Models for Governance, Environment, Social, and ESG Scores (Models 5 to 8)

	Dependent variable: Price			
	Governance	Environment	Social	ESG
	(5)	(6)	(7)	(8)
Treatment	−0.199***	−0.225***	−0.282***	−0.223***
	(0.055)	(0.045)	(0.047)	(0.045)
Post	−0.011	−0.010	−0.010	−0.010
	(0.055)	(0.045)	(0.047)	(0.045)
E/S/G/ESG	−0.001	0.0003	0.0004	−0.00002
	(0.004)	(0.003)	(0.003)	(0.003)
Treatment:Post	−0.375***	−0.332***	−0.333***	−0.332***
	(0.078)	(0.064)	(0.067)	(0.064)
Treatment:E/S/G/ESG	0.017**	0.0178***	0.0248***	0.0185***
	(0.006)	(0.004)	(0.005)	(0.005)
Post:E/S/G/ESG	0.0002	0.00005	0.00007	0.00008
	(0.006)	(0.004)	(0.005)	(0.005)
Treatment:Post:E/S/G/ESG	0.0288***	0.0211***	0.0222**	0.0221***
	(0.009)	(0.006)	(0.007)	(0.006)
Constant	1.158***	1.143***	1.142***	1.146***
	(0.039)	(0.032)	(0.033)	(0.032)
Sample	Europe w/o VW	Europe w/o VW	Europe w/o VW	Europe w/o VW
Observations	360	360	360	360
R^2	0.421	0.507	0.546	0.497
Adjusted R^2	0.410	0.497	0.537	0.487
Residual Std. Error	0.123 (df = 352)	0.113 (df = 352)	0.108 (df = 352)	0.114 (df = 352)
F Statistic	36.61*** (df = 7; 352)	51.64*** (df = 7; 352)	60.56*** (df = 7; 352)	49.70*** (df = 7; 352)

Note: *p<0.1; **p<0.05; ***p<0.01

```r
# Load required packages
library(dplyr)
library(Synth)

# Load your data
df <- read.csv("data.csv", sep = ";")

# Calculate the price relative to the starting price (Trading Day 1)
df <- df %>%
  group_by(Company) %>%
  mutate(StartPrice = first(prccd),
         Price_Relative = prccd / first(prccd))

# Define automotive and control (supermarket) companies
automotive_companies <- c("VOLKSWAGEN AG", "BAYERISCHE MOTOREN WERKE AKT", "BYD COMPANY LTD",
                          "FORD MOTOR CO", "GENERAL MOTORS CO", "HONDA MOTOR CO LTD",
                          "HYUNDAI MOTOR CO LTD", "KIA CORP", "MAZDA MOTOR CORP",
                          "MERCEDES BENZ GROUP AG", "NISSAN MOTOR CO LTD",
                          "PORSCHE AUTOMOBIL HOLDING SE", "Renault SA", "SAIC MOTOR CORP LTD",
                          "STELLANTIS NV", "SUZUKI MOTOR CO LTD", "TATA MOTORS LTD",
                          "TESLA INC", "TOYOTA MOTOR CORP", "VOLVO AB")

control_companies <- c("CARREFOUR SA", "COSTCO WHOLESALE CORP", "KONINKLIJKE AHOLD DELHAIZE",
                       "TARGET CORP", "TESCO PLC", "WALMART INC")

# Initialize list to store results for each company
synth_results <- list()

# Loop over each automotive company
for (company in automotive_companies) {

  # Filter data for the current automotive company and the fixed control group
  df_synth <- df %>%
    filter(Company %in% c(company, control_companies)) %>%
    mutate(unit_id = as.numeric(factor(Company, levels = c(company, control_companies))),
           Trading.Day = as.numeric(Trading.day)) # Ensure Trading.Day is numeric

  # Convert to plain data.frame if not already
```

```
  df_synth <- as.data.frame(df_synth)

  # Define treatment ID for the current automotive company
  treatment_id <- df_synth %>%
    filter(Company == company) %>%
    pull(unit_id) %>%
    unique()

  # Set control IDs to the supermarkets’ unit IDs
  control_ids <- setdiff(unique(df_synth$unit_id), treatment_id)

  # Setup for Synthetic Control Method
  dataprep_synth <- dataprep(
    foo = df_synth,
    predictors = c("Price_Relative"),
    dependent = "Price_Relative",
    unit.variable = "unit_id",
    time.variable = "Trading.Day",
    treatment.identifier = treatment_id,
    controls.identifier = control_ids,
    time.predictors.prior = c(1:179),
    time.optimize.ssr = c(180:248),
    time.plot = 1:248
  )

  # Run the Synthetic Control Method
  synth_out <- synth(dataprep_synth)

  # Compute synthetic prices
  synthetic_prices <- dataprep_synth$Y0plot %*% synth_out$solution.w

  # Store results in a data frame for the current company
  results_df <- data.frame(
    Trading.Day = dataprep_synth$tag$time.plot,
    Company = company,
    Actual_Price_Relative = dataprep_synth$Y1plot,
    Synthetic_Price_Relative = synthetic_prices
  )

  # Append the results to the list with company name as key
  synth_results[[company]] <- results_df
}

# Define the pre-period (15 days before day 180) and post-period (15  days
  after day 180)
pre_period_days <- 165:179
post_period_days <- 180:194
```

```
# Filter, um nur die relevanten Trading.Days zu behalten
relevant_days <- c(pre_period_days, post_period_days)

# Initialize an empty data frame for storing combined results
df_reg <- data.frame()

# Zuordnung von Governance Score zu numerischer Stufe (1-12)
grade_to_numeric <- c(
  "D-" = 1, "D" = 2, "D+" = 3,
  "C-" = 4, "C" = 5, "C+" = 6,
  "B-" = 7, "B" = 8, "B+" = 9,
  "A-" = 10, "A" = 11, "A+" = 12
)

# Loop over each company in ‘synth_results‘ to construct the dataset
for (company in names(synth_results)) {

  # Extract results for the current company and filter by relevant days
  company_data <- synth_results[[company]] %>%
    filter(Trading.Day %in% relevant_days)

  # Extract Governance data only once per company
  governance_data <- df %>%
    filter(Company == company) %>%
    select(Governance.Pillar.Score) %>%
    unique()

  # Berechne Governance_Numeric falls noch nicht vorhanden
  governance_data <- governance_data %>%
    mutate(Governance_Numeric = grade_to_numeric[Governance.Pillar.Score])

  # Actual prices (treatment group)
  actual_data <- company_data %>%
    mutate(
      Company = company,
      Treatment = 1,
      Governance.Pillar.Score = governance_data$Governance.Pillar.Score,
      Governance_Numeric = governance_data$Governance_Numeric,
      Post = ifelse(Trading.Day %in% pre_period_days, 0, 1)
    ) %>%
    select(Trading.Day, Company, X1, Governance.Pillar.Score, Governance_Numeric, Post, Treatment) %>%
    rename(prccd_relative = X1)

  # Synthetic prices (control group)
  control_data <- company_data %>%
```

```r
    mutate(
      Company = company,
      Treatment = 0,
      Governance.Pillar.Score = governance_data$Governance.Pillar.Score,
      Governance_Numeric = governance_data$Governance_Numeric,
      Post = ifelse(Trading.Day %in% pre_period_days, 0, 1)
    ) %>%
    select(Trading.Day, Company, w.weight, Governance.Pillar.Score,
      Governance_Numeric, Post, Treatment) %>%
    rename(prccd_relative = w.weight)

  # Combine actual and synthetic data
  combined_data <- bind_rows(actual_data, control_data)

  # Append to the main dataframe
  df_reg <- bind_rows(df_reg, combined_data)
}

# Display the final dataset
head(df_reg)


library(stargazer)

after_shock_actual <- df_plot$Actual[df_plot$Trading.Day > schock_tag]
after_shock_synthetic <- df_plot$Synthetic[df_plot$Trading.Day > schock_tag
    ]

# Führe einen t-Test durch (VW vs Synth)
t_test_result <- t.test(after_shock_actual, after_shock_synthetic,
    alternative = "two.sided")
print(t_test_result)

# Ergebnisse des T-Tests in einem Data Frame speichern
t_test_results <- data.frame(
  Statistic = c("T-Value", "Degrees␣of␣Freedom", "P-Value", "Mean␣Actual",
    "Mean␣Synthetic"),
  Value = c(
    t_test_result$statistic,
    t_test_result$parameter,
    t_test_result$p.value,
    mean(after_shock_actual, na.rm = TRUE),
    mean(after_shock_synthetic, na.rm = TRUE)
  )
)

# Stargazer zur Darstellung der Ergebnisse verwenden
```

```r
stargazer(t_test_results, type = "latex", summary = FALSE, title = "T-Test Results", rownames = FALSE)



# Installiere und lade das Paket stargazer für die Darstellung

if (!require("stargazer")) install.packages("stargazer")
library(stargazer)

# 1. Modell: prccd_relative ~ Treatment * Post (mit allen Daten)
model_all_data <- lm(prccd_relative ~ Treatment * Post, data = df_reg)

# 2. Modell: prccd_relative ~ Treatment * Post (mit nur europäischen Unternehmen)
european_companies <- c("VOLKSWAGEN AG", "BAYERISCHE MOTOREN WERKE AKT", "STELLANTIS NV",
                         "Renault SA", "VOLVO AB", "PORSCHE AUTOMOBIL HOLDING SE",
                         "MERCEDES BENZ GROUP AG")

df_reg_europe <- df_reg %>% filter(Company %in% european_companies)
model_europe <- lm(prccd_relative ~ Treatment * Post, data = df_reg_europe)

# 3. Modell: prccd_relative ~ Treatment * Post + Treatment * Post * Governance_Numeric (nur europäische Unternehmen)
model_europe_governance <- lm(prccd_relative ~ Treatment * Post + Treatment * Post * Governance_Numeric, data = df_reg_europe)

# 4. Modell: prccd_relative ~ Treatment * Post + Treatment * Post * Governance_Numeric (nur europäische Unternehmen, ohne VW)
df_reg_europe_no_vw <- df_reg_europe %>% filter(Company != "VOLKSWAGEN AG")
model_europe_governance_no_vw <- lm(prccd_relative ~ Treatment * Post + Treatment * Post * Governance_Numeric, data = df_reg_europe_no_vw)

# Darstellung der Modelle in einer stargazer-Tabelle
stargazer(
  model_all_data, model_europe, model_europe_governance, model_europe_governance_no_vw,
  type = "text",
  title = "Regression Models for Treatment and Post Effects",
  add.lines = list(
    c("Sample", "All", "Europe Only", "Europe Only", "Europe w/o VW"),
    c("Governance Interaction", "No", "No", "Yes", "Yes")
  ),
  column.labels = c("All Data", "Europe Only", "Europe + Governance", "Europe + Governance w/o VW"),
```

```r
  dep.var.labels = "prccd_relative"
)

# Numerische Spalten für die ESG-Scores hinzufügen
df_expand <- df %>%
  mutate(
    Governance_Numeric = grade_to_numeric[Governance.Pillar.Score],
    Environment_Numeric = grade_to_numeric[Environmental.Pillar.Score],
    Social_Numeric = grade_to_numeric[Social.Pillar.Score],
    ESG_Numeric = grade_to_numeric[ESG.Score]
  )

# Auswahl relevanter Variablen aus df_main, um die Kontrollvariablen und ESG-Scores zu behalten
df_main_selected <- df_expand %>%
  select(
    Company, Trading.day, Governance_Numeric, Environment_Numeric, Social_Numeric, ESG_Numeric,
    revt, ebitda.teq, act.lct, che.lct, HQ
  )

# Merge df_reg_europe mit den relevanten Variablen aus df_main_selected, basierend auf Company und Trading.Day
df_reg_europe_no_vw <- df_reg_europe_no_vw %>%
  left_join(df_main_selected, by = c("Company", "Trading.Day" = "Trading.day"))

df_reg_europe_no_vw <- df_reg_europe_no_vw %>%
  mutate(
    revt = as.numeric(revt),
    ebitda.teq = as.numeric(ebitda.teq),
    act.lct = as.numeric(act.lct),
    che.lct = as.numeric(che.lct)
  )

# HQ-Standorte nummerieren
df_reg_europe_no_vw <- df_reg_europe_no_vw %>%
  mutate(HQ_Code = case_when(
    HQ == "DEU" ~ 1,
    HQ == "FRA" ~ 2,
    HQ == "NLD" ~ 3,
    HQ == "SWE" ~ 4
  ))

# HQ_Code als Faktor definieren
df_reg_europe_no_vw$HQ_Code <- as.factor(df_reg_europe_no_vw$HQ_Code)

```

```r
# Modellerstellung
# 5. Modell: prccd_relative ~ Treatment * Post + Treatment * Post * Environment_Numeric
model_europe_environment_no_vw <- lm(prccd_relative ~ Treatment * Post + Treatment * Post * Environment_Numeric, data = df_reg_europe_no_vw)
summary(model_europe_environment_no_vw)

# 6. Modell: prccd_relative ~ Treatment * Post + Treatment * Post * Social_Numeric
model_europe_social_no_vw <- lm(prccd_relative ~ Treatment * Post + Treatment * Post * Social_Numeric, data = df_reg_europe_no_vw)
summary(model_europe_social_no_vw)

# 7. Modell: prccd_relative ~ Treatment * Post + Treatment * Post * ESG_Numeric
model_europe_esg_no_vw <- lm(prccd_relative ~ Treatment * Post + Treatment * Post * ESG_Numeric, data = df_reg_europe_no_vw)
summary(model_europe_esg_no_vw)

# 8. Modell: Governance + Kontrollvariablen (revt, ebitda.teq, act.lct, che.lct)
model_europe_governance_controls_no_vw <- lm(prccd_relative ~ Treatment * Post + Treatment * Post * Governance_Numeric.y + revt + ebitda.teq + act.lct + che.lct, data = df_reg_europe_no_vw)
summary(model_europe_governance_controls_no_vw)


# 9. Modell: Governance + Fixed Effects
model_europe_governance_fe_no_vw <- lm(prccd_relative ~ Treatment * Post + Treatment * Post * Governance_Numeric.y + factor(Company) + factor(Trading.Day), data = df_reg_europe_no_vw)
summary(model_europe_governance_fe_no_vw)

# 10. Modell: Governance + Kontrollvariablen + Fixed Effects
model_europe_governance_controls_fe_no_vw <- lm(prccd_relative ~ Treatment * Post + Treatment * Post * Governance_Numeric.y + revt + ebitda.teq + act.lct  + che.lct + factor(Company) + factor(Trading.Day), data = df_reg_europe_no_vw)
summary(model_europe_governance_controls_fe_no_vw)

# Load necessary libraries
if(!require(lmtest)) install.packages("lmtest", dependencies=TRUE)
if(!require(car)) install.packages("car", dependencies=TRUE)
if(!require(plm)) install.packages("plm", dependencies=TRUE)

library(lmtest)
library(car)
```

```r
library(plm)

# List of models that are already defined in your R environment
models <- list(
  model_all_data,
  model_europe,
  model_europe_governance,
  model_europe_governance_no_vw,
  model_europe_environment_no_vw,
  model_europe_social_no_vw,
  model_europe_esg_no_vw,
  model_europe_governance_controls_no_vw,
  model_europe_governance_fe_no_vw,
  model_europe_governance_controls_fe_no_vw
)

# Model names for output labeling
model_names <- c(
  "model_all_data",
  "model_europe",
  "model_europe_governance",
  "model_europe_governance_no_vw",
  "model_europe_environment_no_vw",
  "model_europe_social_no_vw",
  "model_europe_esg_no_vw",
  "model_europe_governance_controls_no_vw",
  "model_europe_governance_fe_no_vw",
  "model_europe_governance_controls_fe_no_vw"
)

# Run diagnostic tests for each model
for (i in seq_along(models)) {
  cat("\n", "####␣Model:", model_names[i], "####", "\n")

  model <- models[[i]]

  # 1. Breusch-Pagan Test
  cat("Breusch-Pagan␣Test:\n")
  print(bptest(model))

  # 2. Breusch-Godfrey Test for Autocorrelation
  cat("Breusch-Godfrey␣Test:\n")
  print(bgtest(model))

  # 3. Ramsey RESET Test
  cat("Ramsey␣RESET␣Test:\n")
  print(resettest(model))
```

```
  # 4. Shapiro-Wilk Test for Normality of Residuals
  cat("Shapiro-Wilk␣Test:\n")
  print(shapiro.test(residuals(model)))

  # 5. Variance Inflation Factor (VIF) for Multicollinearity (skip if model has aliased coefficients)
  cat("VIF:\n")
  tryCatch({
    print(vif(model))
  }, error = function(e) {
    cat("VIF␣cannot␣be␣calculated␣due␣to␣aliased␣coefficients␣or␣other␣issues.\n")
  })
}

# Load necessary libraries
library(ggplot2)
library(dplyr)

# Annahme: Definieren eines Schwellenwerts, um "gute" und "schlechte" Governance-Scores zu unterscheiden
threshold <- 10

# Neue Spalte erstellen, um "gute" und "schlechte" Governance-Scores zu kennzeichnen
df_goodbad <- df_goodbad %>%
  mutate(Governance_Group = case_when(
    Governance_Numeric.x >= threshold ~ "Good␣G␣Score",
    TRUE ~ "Poor␣G␣Score"
  ))

# Durchschnitt der relativen Preise für jede Gruppe (Treatment und Control) berechnen und auf den Startwert indexieren
df_avg <- df_goodbad %>%
  group_by(Trading.Day, Treatment, Governance_Group) %>%
  summarise(avg_prccd_relative = mean(prccd_relative * 100, na.rm = TRUE)) %>%
  ungroup() %>%
  mutate(Group = case_when(
    Treatment == 0 ~ "Control",
    Treatment == 1 & Governance_Group == "Good␣G␣Score" ~ "Treatment␣(Good␣G␣Score)",
    Treatment == 1 & Governance_Group == "Poor␣G␣Score" ~ "Treatment␣(Poor␣G␣Score)"
  )) %>%
  group_by(Group) %>%
```

```
  mutate(indexed_price = avg_prccd_relative / first(avg_prccd_relative) * 100) %>%
  ungroup()

# Find the shock day (first Trading.Day where Post == 1)
shock_day <- min(df_goodbad$Trading.Day[df_goodbad$Post == 1])

# Plotting
ggplot(df_avg, aes(x = Trading.Day, y = indexed_price, color = Group)) +
  geom_line(size = 1) +
  geom_vline(xintercept = shock_day, linetype = "dashed", color = "red") +
  labs(title = "Indexed Average Relative Price by Trading Day for Treatment and Control with Good and Poor G Scores",
       x = "Trading Day",
       y = "Indexed Average Relative Price (Start = 100)",
       color = "Group") +
  scale_color_manual(values = c("Control" = "blue",
                                "Treatment (Good G Score)" = "green",
                                "Treatment (Poor G Score)" = "purple")) +
  theme_minimal() +
  theme(legend.position = "bottom")

# Exportiere die Daten als .dat-Datei
write.table(df_avg[, c("Trading.Day", "Group", "indexed_price")],
            file = "data_plot.dat",
            row.names = FALSE,
            col.names = TRUE,
            sep = "\t",
            quote = FALSE)

# Load necessary packages
if (!require("tidyverse")) install.packages("tidyverse")
library(tidyverse)

# Define the mapping for the letter grades to numeric scores (1-12 scale)
grade_to_score <- c("A+" = 12, "A" = 11, "A-" = 10,
                    "B+" = 9, "B" = 8, "B-" = 7,
                    "C+" = 6, "C" = 5, "C-" = 4,
                    "D+" = 3, "D" = 2, "D-" = 1,
                    "na" = NA)  # Set NA for missing data

# Read the data
esg_data <- read.csv("ESG.csv", sep = ";")

# Select relevant columns and rename them
esg_data <- esg_data %>%
  select(Company, Environmental_Pillar_Score = Environmental.Pillar.Score..
```

```
    Weight.34.1..,
          Social_Pillar_Score = Social.Pillar.Score..Weight.41.5..,
          Governance_Pillar_Score = Governance.Pillar.Score..Weight.24.4..)

# Convert the letter grades to numeric scores using the 1-12 scale
esg_data <- esg_data %>%
  mutate(
    Environmental_Pillar_Score = grade_to_score[Environmental_Pillar_Score
   ],
    Social_Pillar_Score = grade_to_score[Social_Pillar_Score],
    Governance_Pillar_Score = grade_to_score[Governance_Pillar_Score]
  )

# Calculate and display the correlation matrix
cor_matrix <- esg_data %>%
  select(Environmental_Pillar_Score, Social_Pillar_Score, Governance_Pillar
   _Score) %>%
  cor(use = "complete.obs")

print(cor_matrix)
```

Listing 6.1: R Code for Data Analysis

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